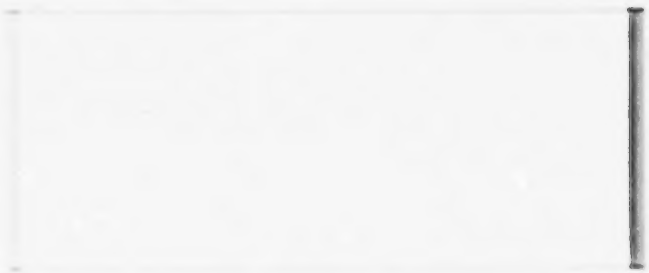

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INSTRUCTION MANUAL

FOR

CONDUCTANCE AND DILATOMETRY UNIT

(Ash Testing Unit Model 78911)

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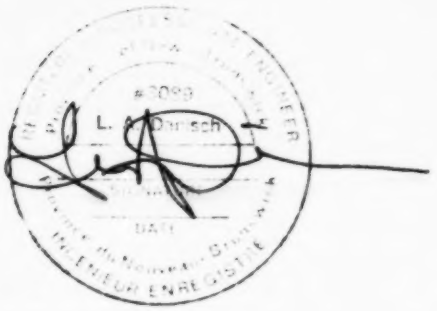

For:

PTL Research Ltd.
286 Restigouche Road
Oromocto, New Brunswick
E2V 2H5

67p

Under Contract to:

Supply and Services
Canada:
DSS File No. 07SQ.23440-4-9286
Contract Ser. No. 0SQ85-00258

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No. E/87/21
March 20, 1987
LAD/lad

WARNING

The Conductance and Dilatometry Unit is carefully designed and constructed to be used as laboratory equipment. Reasonable precautions have been taken to protect the user from harm due to high temperatures, high voltages, pressurized gas, mechanical fixtures, and the like. However, laboratory equipment of this type is inherently dangerous, and neither the supplier nor any subcontractors shall be responsible for loss, damage or liability resulting from use or possession of this equipment. The user is advised to take precautions to prevent unauthorized persons from gaining access to the equipment, and to exercise extreme caution when using or working on the equipment. Anyone using the equipment should first become thoroughly familiar with it by studying this manual and the manuals, data sheets, and drawings associated with the individual components; and then thoroughly studying the equipment, first with all power shut off, and then with all equipment except the two furnaces powered on (green OVERTEMP OK lamp extinguished and GAS PRE-HEATING TEMPERATURE CONTROLLER setpoint at 0 degrees celsius--Refer to DESCRIPTION and OPERATION Sections). Only after thoroughly understanding the equipment, should the user attempt to use it with the furnaces on.

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1.0 INTRODUCTION

The Conductance and Dilatometry Unit (also referred to as the Ash Testing Unit, Model 78911), was designed and built by the New Brunswick Research and Productivity Council (RPC) for CANMET, EMR Canada according to specifications given in contract 0SQ85-00258 issued by Supply and Services Canada to PTL Research Ltd. The apparatus measures the temperature at which a significant change in volume or electrical conductance occurs in a lightly compacted sample of coal ash. The unit is shown in Figure 1.

The relationship between the above changes and the temperature of the sample can be used as an indication of the propensity of various coals to cause slagging and fouling in furnaces, boilers, and the like. It can be important to measure both the conductance and dilation because some samples of coal ash exhibit changes in conductance associated with sintering, without changing significantly in volume.

The instrument developed includes an electric furnace to heat a small crucible holding a lightly compacted sample of coal ash. The conductance of the ash is measured by means of an AC signal applied through two platinum plates in contact with the top and bottom of the sample. The change in volume is measured by a Linear Variable Differential Transformer (LVDT) which contacts the top of the sample through a refractory probe.

Preheated air or nitrogen can be delivered to the crucible environment to control the degree of oxidation or reduction of the sample.

A typical sample run involves continuous measurement of dilation, conductance, and temperature while the sample temperature is increased in a controlled manner. Curves of these variables versus time may then be used to obtain curves of "dilation" (vertical dimension) and conductance versus sample temperature. These curves may be analyzed to determine the sintering characteristics of the sample,When significant sintering occurs, as evidenced by a change in dilation, the sample is cooled and removed.

The instrument is designed for ease of operation, having separately moveable furnace and measurement probe assemblies. All process parameters are varied by microprocessor-based controllers.

2.0 DESCRIPTION

2.1 GENERAL

For a detailed description of the individual components of the Conductance and Dilatometry Unit, please refer to the individual manuals and data sheets appended to the master copy of this manual.

The entire Conductance and Dilatometry Unit, shown in Figure 1, is mounted on a wheeled cart . The lower section of the cart holds most of the gas delivery and preheating equipment. The upper section holds an instrument cabinet and a support assembly. The instrument cabinet contains most of the electronic equipment and some of the gas delivery equipment, and the support assembly holds the furnace used to heat the sample and the transducers associated with dilation and conductance.

Fig. 2 shows the front-panel layout of the instrument cabinet. The electrical interconnection of the various pieces of equipment is shown in Fig. 3. Figures 4 and 5 show the construction of the stand assembly and probe assembly respectively, refractory parts used to hold and interface to the ash sample. Figures 6 through 9 describe the circuitry of the conductance meter, which includes custom electronics contained in an Electronic Interface Unit (also in Figure 6). The Electronic Interface Unit also includes circuitry to amplify the crucible signal for chart recording or data-logging. Figures 10 through 12 show various mechanical details of the instrument, clarifying details of adjustment and use. Figure 13 details the writing of a sample program segment for the main temperature controller.

Titles of parts and sub-assemblies referred to in the figures are capitalized in the text, to remind the reader to refer to the figures. At least the first instance of each such item below also carries an alphanumeric reference keyed to the figures. For a complete understanding of the instrument, please also refer to the other sections of this manual, especially OPERATION and SPECIFICATIONS.

FIGURES 1-12

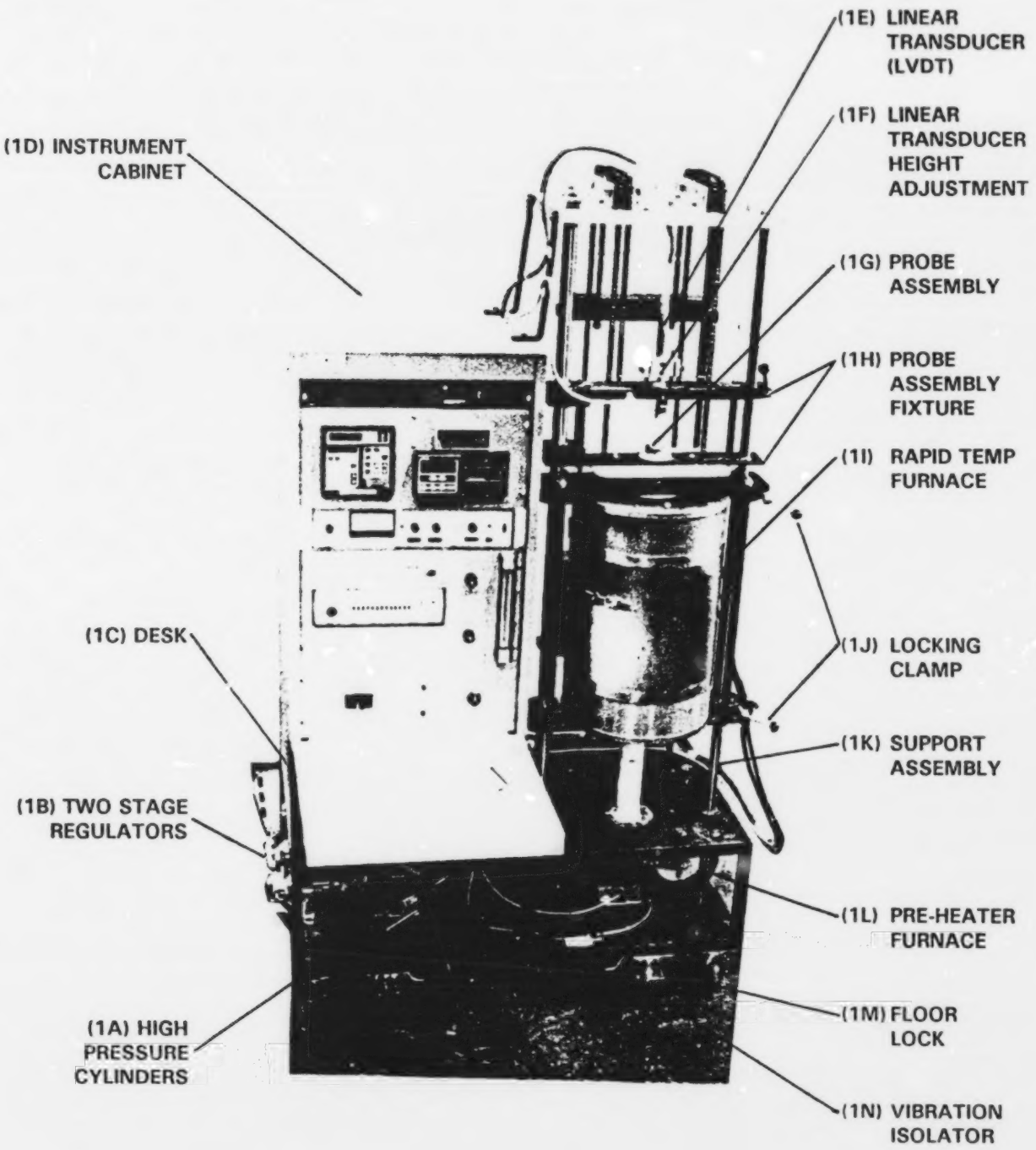


Figure 1 - Conductance and Dilatometry Unit

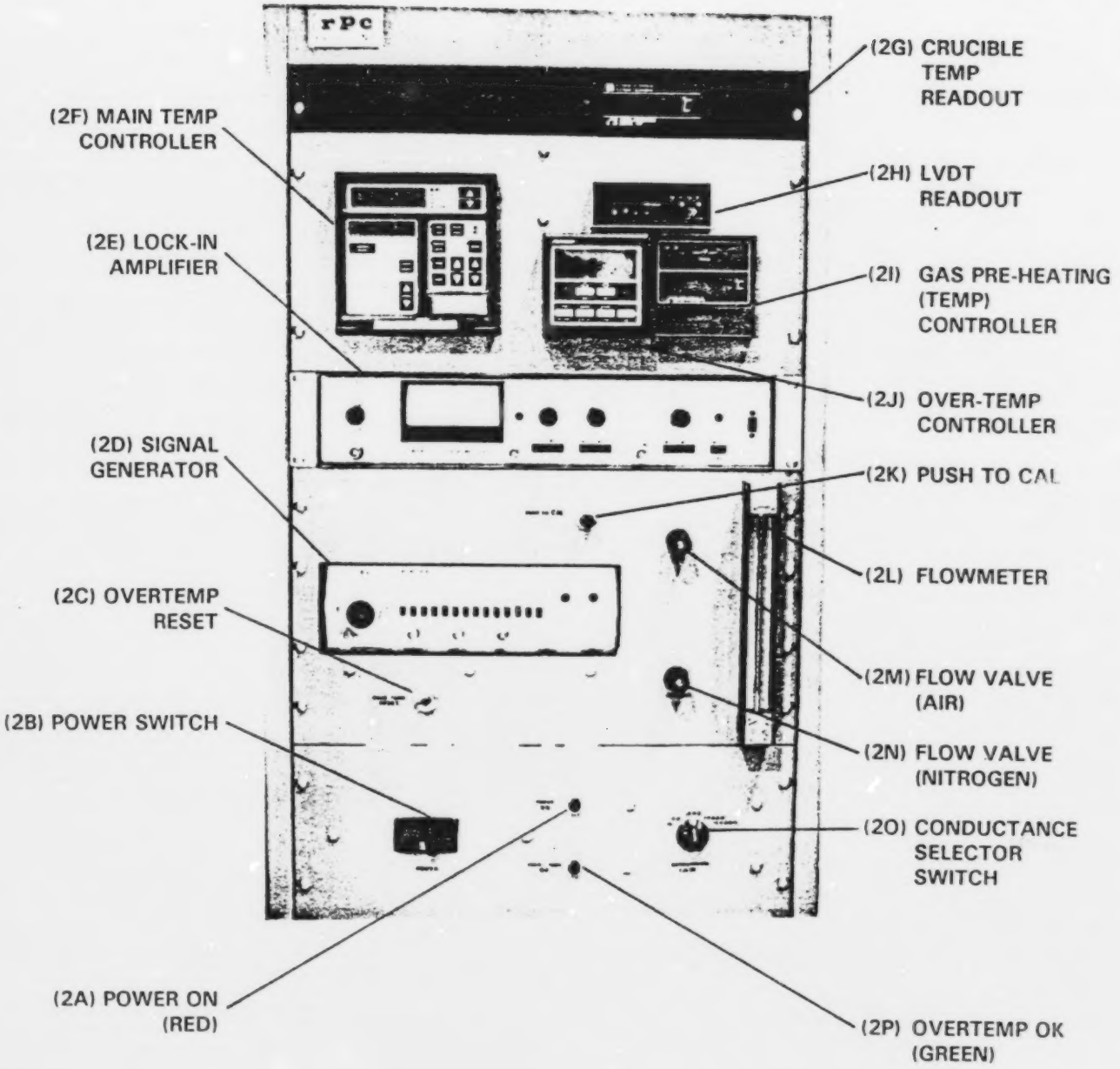


Figure 2 - Front Panel of Instrument Cabinet

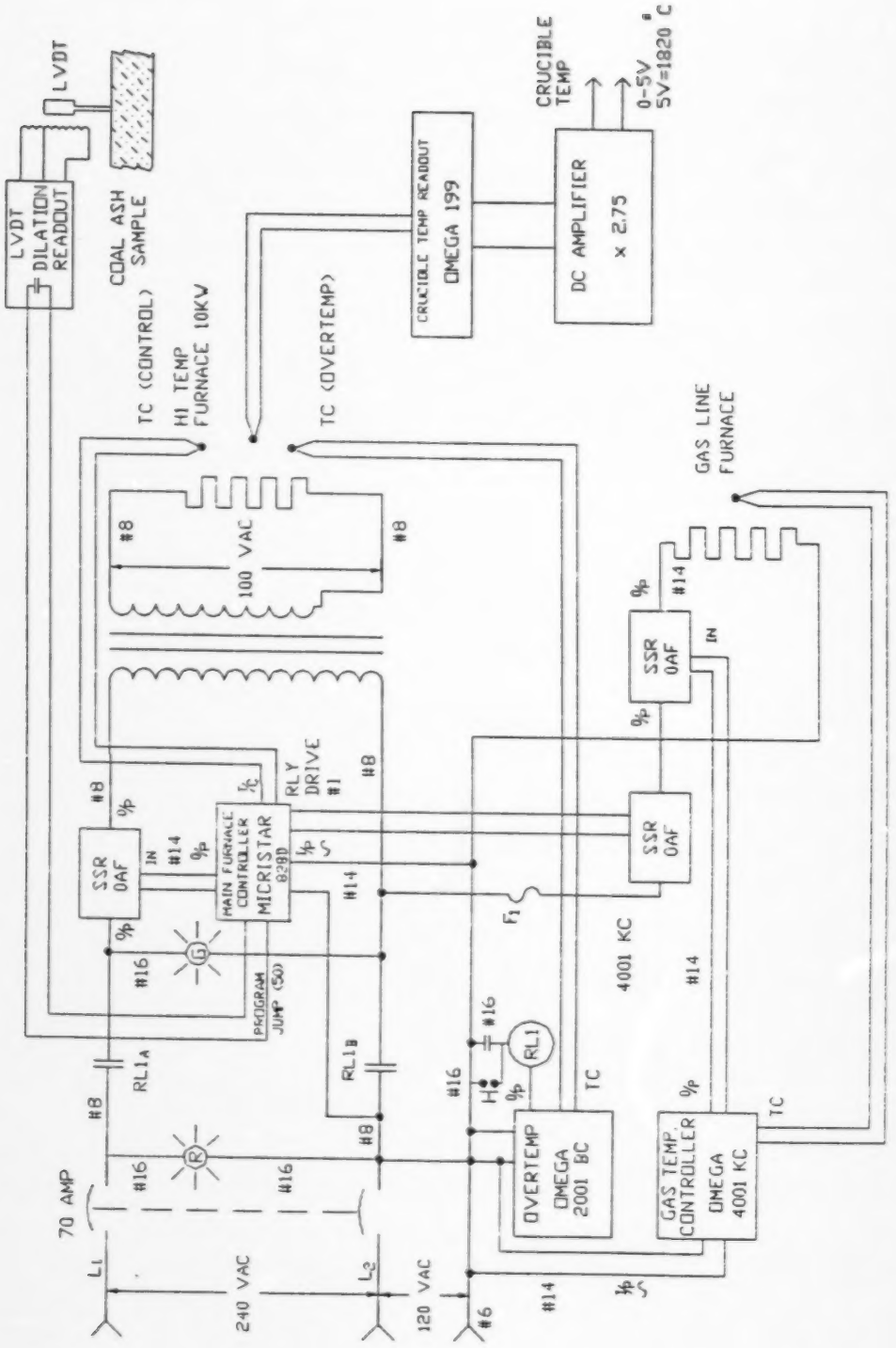


Figure 3 - Wiring Diagram of Measurement and Control Systems For Dilation and Temperature

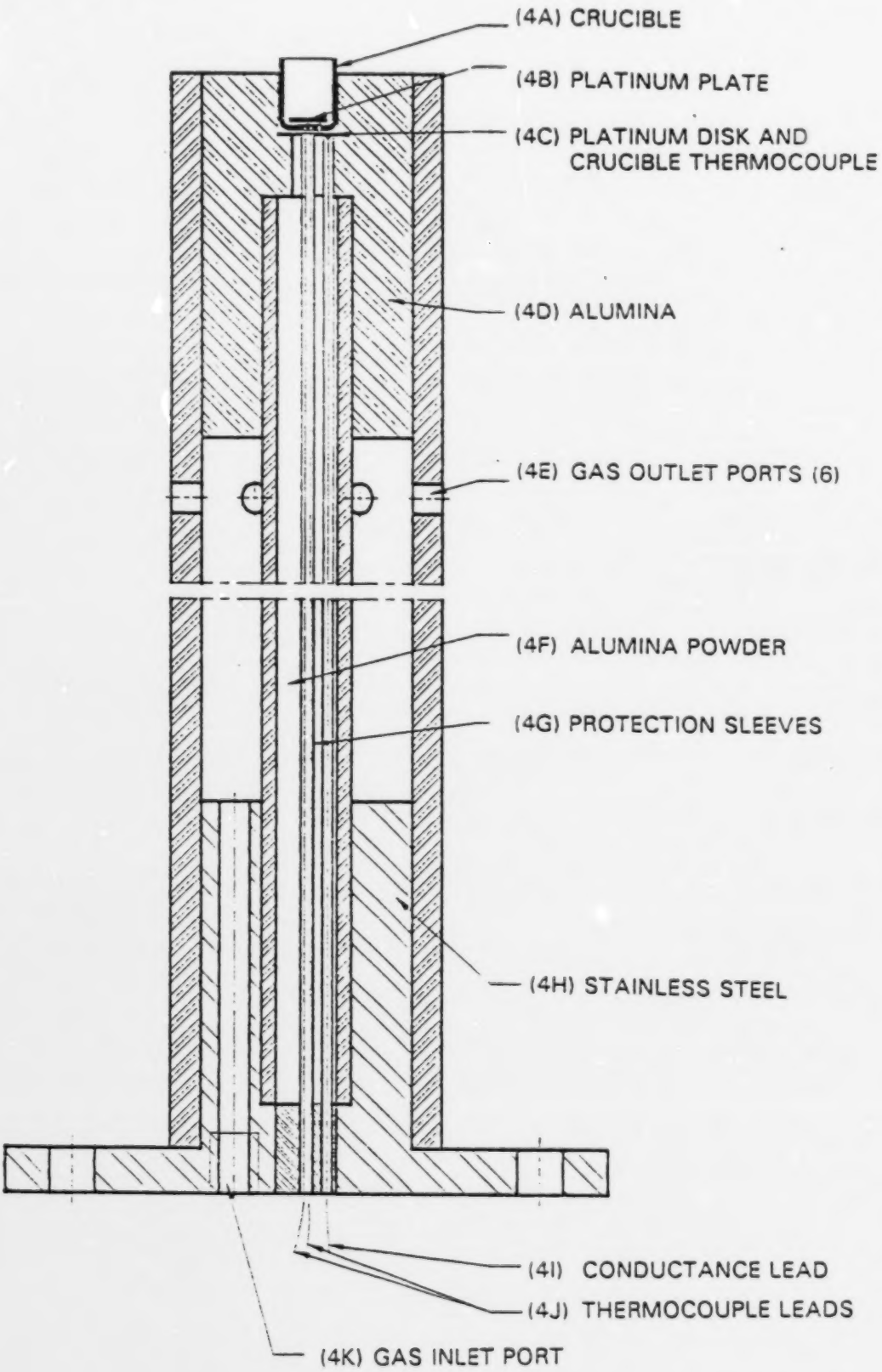


Figure 4-Stand Assembly

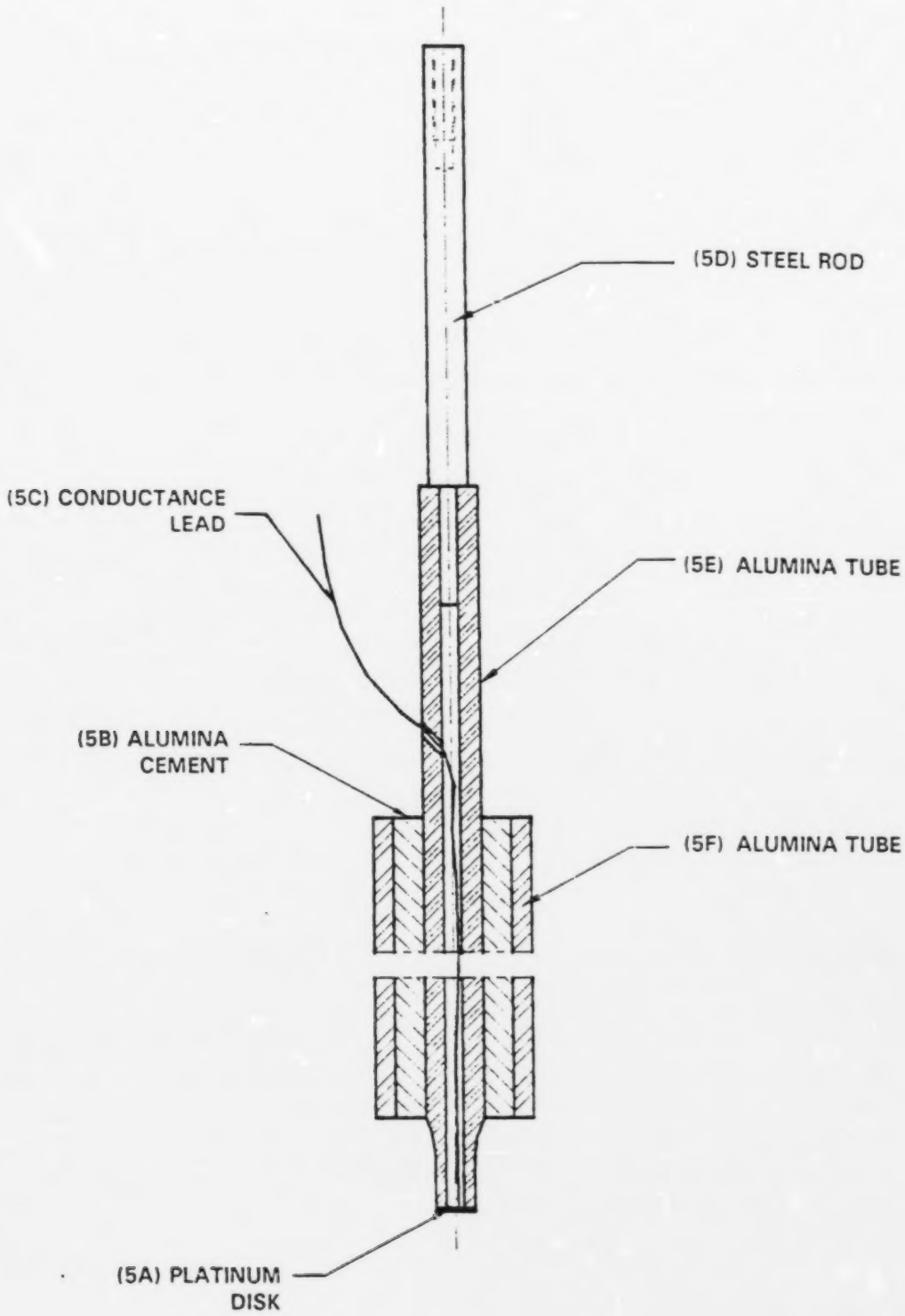


Figure 5-Probe Assembly

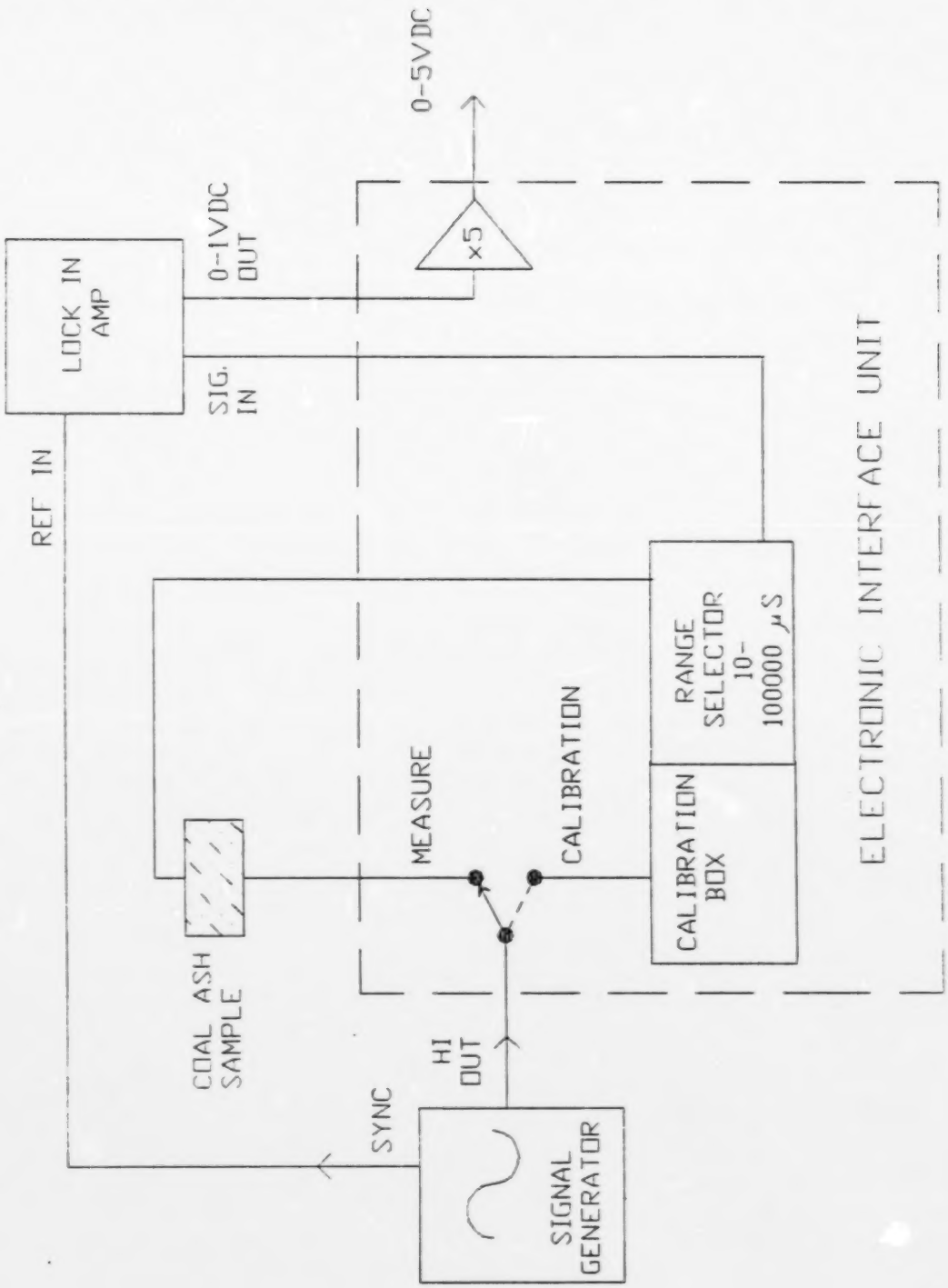
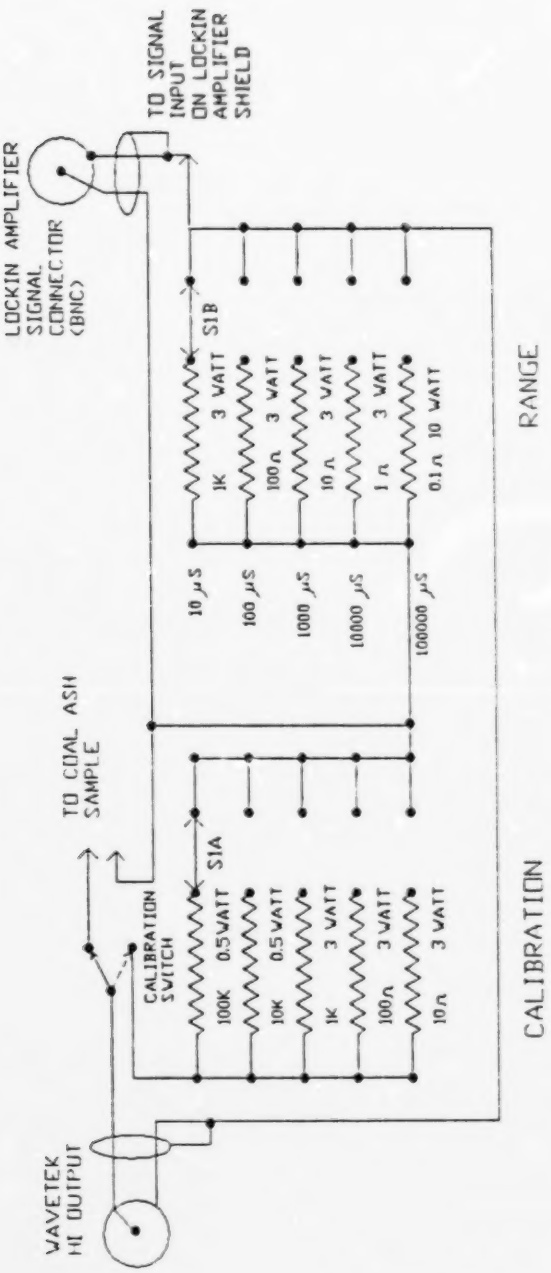
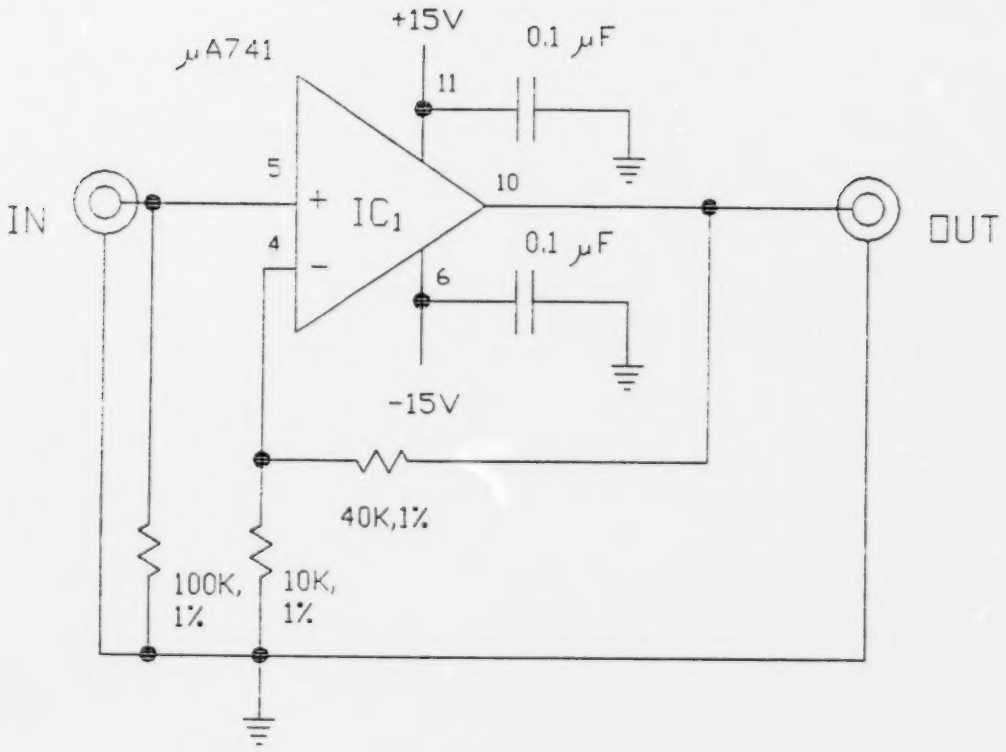


Figure 6 - Block Diagram-Conductance Meter Circuitry



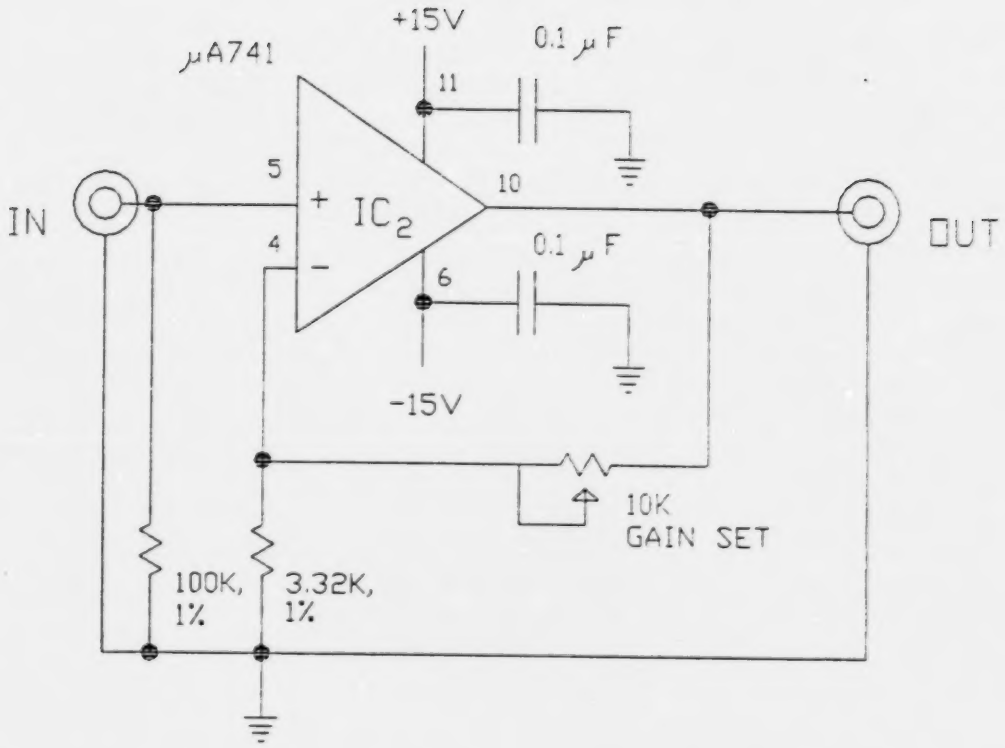
Note : Contained in Electronic Interface Unit

Figure 7 - Circuit Diagram - Calibration and Range Portion of Conductance Meter



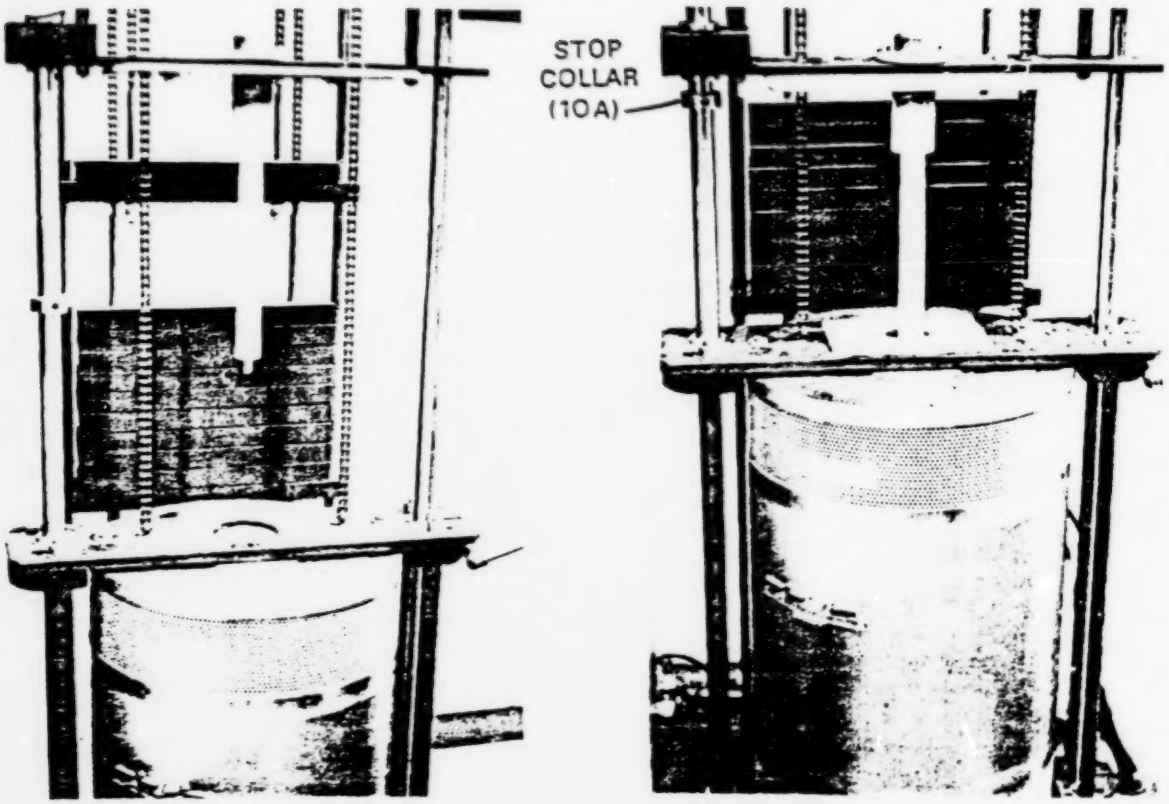
NOTE : VOLTAGE GAIN = x 5
Contained in Electronic Interface Unit

Figure 8 - Circuit Diagram - Chart Recorder Amplifier for Conductance Meter



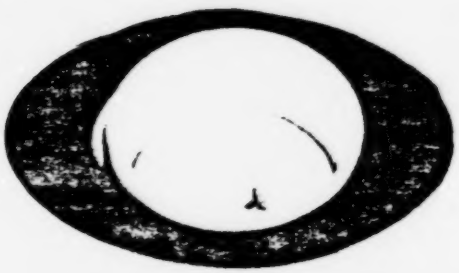
Note : VOLTAGE GAIN = x 2.86
Contained in Electronic Interface Unit

Figure 9 - Circuit Diagram - Chart Recorder Amplifier for Crucible Temperature



PROBE UP

PROBE LOWERED



CRUCIBLE IN SUPPORT ASSEMBLY

Figure 10 - Lowering the Probe

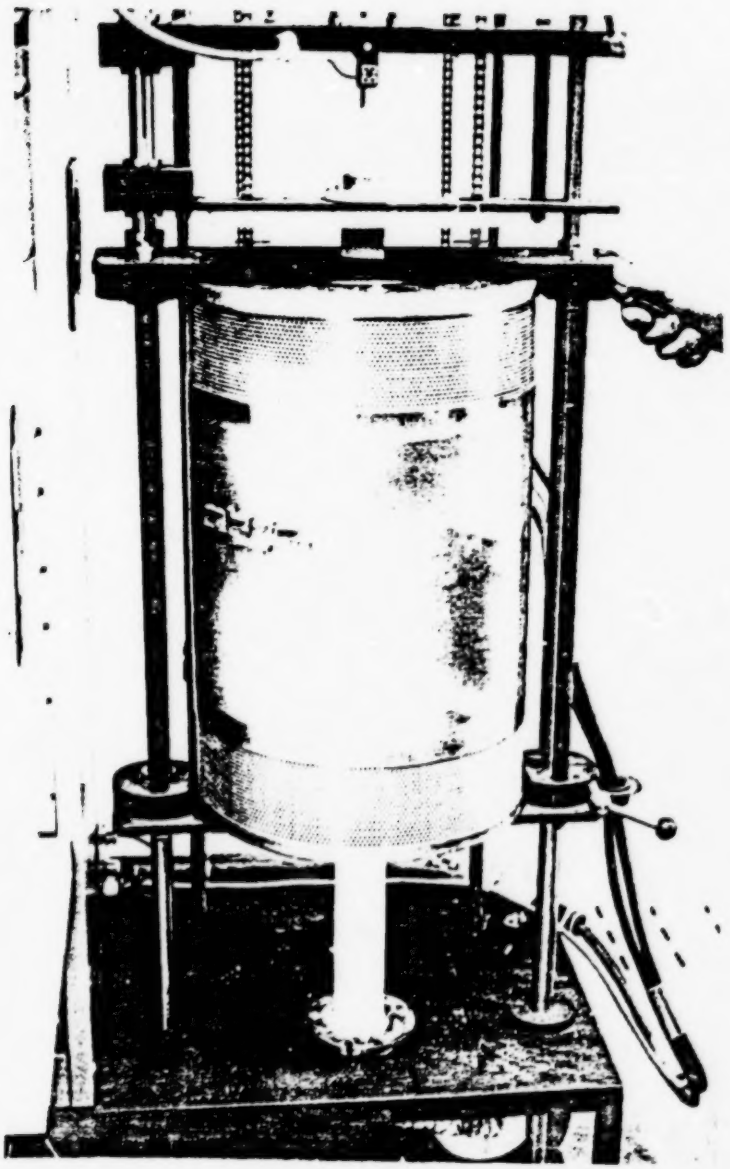
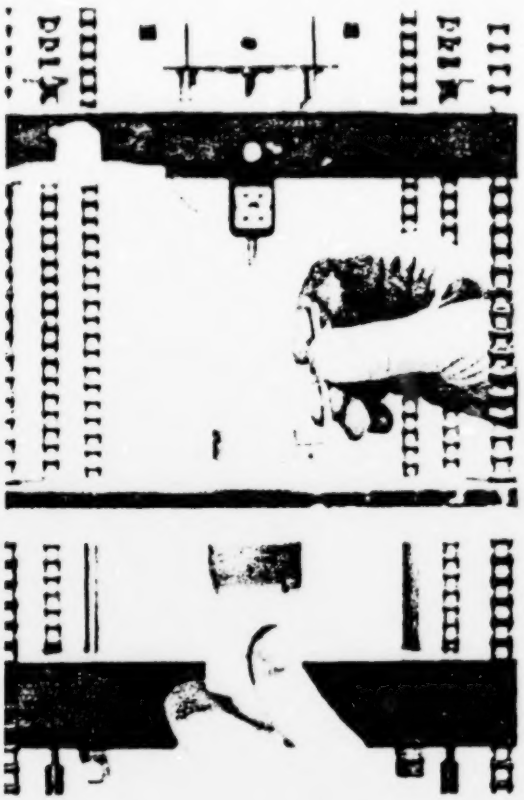
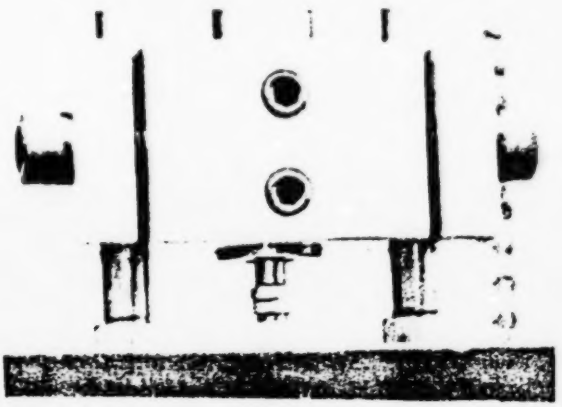


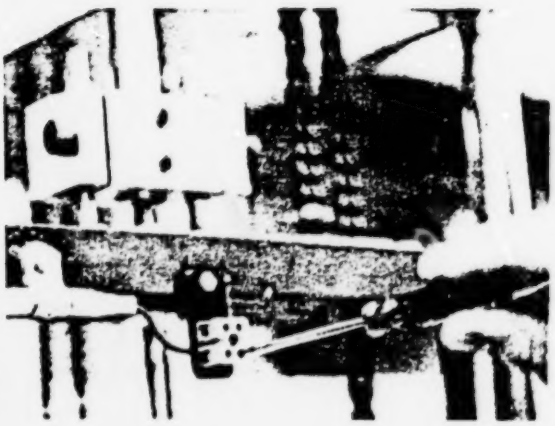
Figure 11 - Raising the Furnace



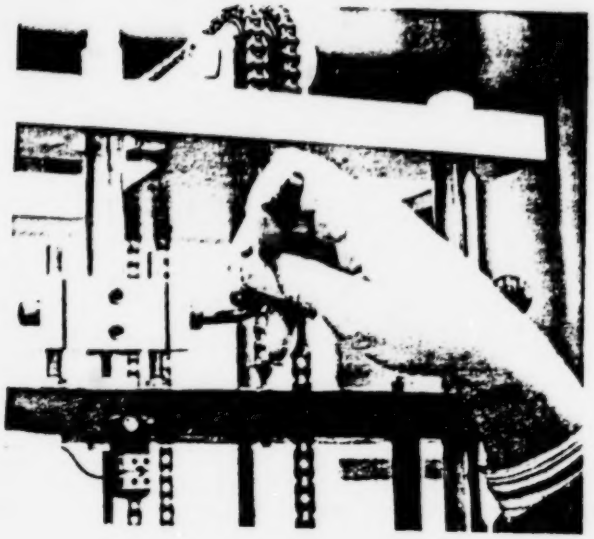
LOCKING COLLAR ADJUSTMENT



PROBE-LINEAR TRANSDUCER JOIN



CONDUCTANCE LEAD TERMINAL



LINEAR
TRANSDUCER
HEIGHT
ADJUSTMENT

Figure 12 - Probe Adjustment

2.2 INDIVIDUAL COMPONENTS

The components of the Unit include:

2.2.1 SUPPORT ASSEMBLY

-a SUPPORT ASSEMBLY (1K) on which are mounted the RAPID TEMP FURNACE (1I) and the PROBE ASSEMBLY (1G). The SUPPORT ASSEMBLY has four round vertical shafts. The RAPID TEMP FURNACE and the PROBE ASSEMBLY fixture slide up and down (separately) on the two front shafts. Counterbalancing weights slide up and down over the rear two shafts.

2.2.2 RAPID TEMP FURNACE SYSTEM

-a RAPID TEMP FURNACE (1I), capable of heating samples of coal ash to 1600 degrees celsius. The RAPID TEMP FURNACE is mounted on the SUPPORT ASSEMBLY and can be lowered for access to the sample of coal ash if the lower two hand--operated clamps at the side of the SUPPORT ASSEMBLY are loosened. The RAPID TEMP FURNACE is counterbalanced by the lower of two sets of weights at the rear of the SUPPORT ASSEMBLY. There are two thermocouples that project into the side of the RAPID TEMP FURNACE. The one toward the rear is used in conjunction with the MAIN TEMPERATURE CONTROLLER (2F) to sense element temperature. The other thermocouple is used in conjunction with the OVER-TEMPERATURE CONTROLLER (2J) to prevent damage to the furnace should control be lost for any reason. A large transformer in the bottom of the INSTRUMENT CABINET (1D) supplies 100 volt power to the elements of the furnace.

-a MAIN TEMPERATURE CONTROLLER (2F) for the RAPID TEMP FURNACE, capable of controlling the element temperature at a given level, as well as for controlled rates of increase and decrease. The MAIN TEMPERATURE CONTROLLER is located in the INSTRUMENT CABINET (1D). It controls the temperature measured by a type B thermocouple inserted through the side of the RAPID TEMP FURNACE, in close proximity to the heating elements. The element temperature may be read on the front panel of the MAIN TEMPERATURE CONTROLLER and is also available as an analog signal for chart recording or datalogging (See below). The MAIN TEMPERATURE CONTROLLER also receives input from the circuit for measuring dilation, so that it can begin a controlled cool-down step when a preset dilation value is achieved.

-an OVER-TEMPERATURE CONTROLLER (2J; located in the INSTRUMENT CABINET) that shuts off the RAPID TEMP FURNACE power if the temperature of the RAPID TEMP FURNACE elements exceeds a setpoint (normally set 100 to 200 degrees above the highest temperature expected from the furnace-- See OPERATION Section). The OVER-TEMPERATURE CONTROLLER receives its input from a type B thermocouple inserted through the side of the RAPID TEMP FURNACE near the thermocouple for the MAIN TEMPERATURE CONTROLLER. The OVER-TEMPERATURE CONTROLLER may indicate a somewhat different temperature than that indicated by the MAIN TEMPERATURE CONTROLLER, because the two different thermocouples are not in exactly the same location with respect to the elements. Do not use the OVER-TEMPERATURE CONTROLLER to judge the exact element temperature.

2.2.3 GAS DELIVERY SYSTEM

-provision for two HIGH PRESSURE CYLINDERS (1A; not supplied with the instrument), for the supply of nitrogen and air, to be mounted in the lower section of the instrument cart. The gases are used to control the atmosphere surrounding the crucible containing the sample of coal ash.

-two TWO STAGE REGULATORS (1B) which are mounted on the HIGH PRESSURE CYLINDERS and are used to set the maximum pressure level of the gas delivery system and to shut off the gas supply when it is not being used.

-two AUXILIARY SHUTOFF VALVES (Not shown in the figures) mounted on the TWO STAGE REGULATORS. It is recommended that these valves be left open at all times, and the TWO STAGE REGULATORS be used to shut off the gas supply. The AUXILIARY SHUTOFF VALVES are provided for the convenience of the user, should they elect to use gas delivered by hoses from another source.

CAUTION

Because of the inherent danger of pressurized gases, the supplier of the instrument assumes no responsibility for this or any other changes made to the gas system by the user, nor for any deleterious results of the use of any gases in the system (Please refer to the WARNING at the beginning of this manual).

-two FLOW VALVES (2M,2N), used for AIR and NITROGEN. These valves are used to set the flow rate of the gas mixture delivered to the vicinity of the sample crucible.

-a FLOWMETER (2L) of the rotameter type, containing a glass (black) float and a stainless steel (silver-colored) float. The FLOWMETER has a scale of 0 to 150 millimeters. The two different floats, which may be used at the same time, allow one to read the rate of the gas flow over two different ranges. Normally, the stainless steel ball is read. The glass ball is useful in reading very low flow rates. The appended data sheets for the FLOWMETER are used to convert the FLOWMETER indication in millimeters to gas flow (liters/min. or cubic feet/hour) for the particular gas or gases in use at the time.

-a PRE-HEATER FURNACE (1L) located in the lower section of the cart, for heating the gas before it reaches the crucible.

-a GAS PRE-HEATING TEMPERATURE CONTROLLER (2I; located in the INSTRUMENT CABINET) which controls the PRE-HEATER FURNACE to a setpoint selected by the operator. In order to operate, the PRE-HEATER FURNACE must receive a signal from the MAIN TEMPERATURE CONTROLLER. For every program segment in which it is desired to preheat the gases, EVENT 1 must be programmed ON in the MAIN TEMPERATURE CONTROLLER. EVENT 1 ON causes a solid-state relay to close, allowing power to flow to the PRE-HEATER FURNACE, provided the GAS PRE-HEATING TEMPERATURE CONTROLLER is calling for a temperature increase (See interconnections in Fig. 3).

2.2.4 SAMPLE-HOLDING SYSTEM

-a STAND ASSEMBLY (Figure 4), mounted in a fixed position on the instrument cart, which is used to hold the CRUCIBLE (4A) containing the sample of ash. The center line of the STAND ASSEMBLY is coincident with that of the RAPID TEMP FURNACE. When the RAPID TEMP FURNACE is fully raised, the ash sample is in the middle of its isothermal zone. When the RAPID TEMP FURNACE is lowered, the ash sample is accessible to the operator at the top of the STAND ASSEMBLY. The STAND ASSEMBLY contains and supports the THERMOCOUPLE LEADS (4J) for the CRUCIBLE THERMOCOUPLE (4C). It also contains and supports a CONDUCTANCE LEAD (4I) for a PLATINUM DISK (4C) used to make electrical connection with a platinum wire (See description of the alumina CRUCIBLE below) which is in contact with the square PLATINUM PLATE (4B) at the bottom of the crucible. The PLATINUM DISK has a hole in the centre, through which passes the CRUCIBLE THERMOCOUPLE. The PLATINUM DISK is welded to its CONDUCTANCE LEAD. The STAND ASSEMBLY also conveys gas to the vicinity of the crucible. The gas enters at the bottom of the assembly at a GAS INLET PORT (4K) and exits the STAND ASSEMBLY through six GAS OUTLET PORTS (4E) evenly spaced around the assembly and below the CRUCIBLE. The gas then rises past the CRUCIBLE, contained between the STAND ASSEMBLY and the inner refractory tube of the RAPID TEMP FURNACE. The STAND ASSEMBLY is made of alumina, with a steel base. The CONDUCTANCE LEAD passes through one channel in an alumina two--channel thermocouple PROTECTION SLEEVE (4G) mounted in the inner core of the STAND ASSEMBLY. The leads for the CRUCIBLE THERMOCOUPLE pass through the two channels of a similar PROTECTION SLEEVE mounted next to the one for the CONDUCTANCE LEAD, along the center line of the STAND ASSEMBLY (See MAINTENANCE Section). Any of these leads may be removed and replaced *in situ*, without disassembling the STAND ASSEMBLY. The inner core of the STAND ASSEMBLY is filled with alumina powder to support the protection sleeves and to prevent thermal convection currents.

-an alumina CRUCIBLE (4A), which is used to hold the samples of ash. The CRUCIBLE has a "central hole" in the bottom and an "offset hole," also in the bottom. The CRUCIBLE is placed in the circular well at the top of the STAND ASSEMBLY (Fig. 4). The CRUCIBLE contains a square PLATINUM PLATE (4B) which fits snugly into the bottom and forms the bottom conductor in contact with the ash sample for measuring conductance. The PLATINUM PLATE is on top of and in contact with a platinum wire formed into an open circular shape lying flat in the bottom of the CRUCIBLE. The wire passes through the "offset hole" in the bottom of the CRUCIBLE, and is bent to run a short distance in contact with the outside bottom of the CRUCIBLE. Refractory cement in the hole holds the wire in place. When the CRUCIBLE is in place in the STAND ASSEMBLY, this end of the wire contacts the PLATINUM DISK (4C) at the top of the STAND ASSEMBLY. The "central hole" fits over the CRUCIBLE THERMOCOUPLE at the bottom of the well in the STAND ASSEMBLY. The CRUCIBLE THERMOCOUPLE is in close proximity to, but does not touch, the square PLATINUM PLATE in the CRUCIBLE. The CRUCIBLE has inside dimensions of 7.8 mm (diameter) and 14 mm (depth).

2.2.5 CRUCIBLE TEMPERATURE READOUT SYSTEM

-a CRUCIBLE TEMPERATURE READOUT (2G) in the INSTRUMENT CABINET, which is connected to the CRUCIBLE THERMOCOUPLE. It displays crucible temperature linearly from 335 to 1750 degrees celsius with an accuracy of +/- 2.3 percent. It also has an analog output which is conditioned by a CHART RECORDER AMPLIFIER (Figure 8) so that 0 to 5 volts corresponds to 0 to 1750 degrees.

2.2.6 DILATOMETRY SYSTEM

-a PROBE ASSEMBLY (Figure 5), located immediately above the ash sample, which is used to transmit the change in vertical dimension of the sample to the LINEAR TRANSDUCER (1E). The PROBE ASSEMBLY includes a PLATINUM DISK (5A) welded to a platinum CONDUCTANCE LEAD (5C). The PLATINUM DISK rests on top of the ash sample and is part of the circuit to measure conductance. The PROBE ASSEMBLY is made of alumina, with a STEEL ROD (5D) at the top that attaches to the LINEAR TRANSDUCER mounted above it. The PROBE ASSEMBLY is free to move vertically, passing through a loosely-fitted ceramic collar below the LINEAR TRANSDUCER HEIGHT ADJUSTMENT fixture (Fig. 12). A steel LOCKING COLLAR (Figure 12) with an Allen set screw is used to prevent the PROBE ASSEMBLY from dropping more than a set amount when the frame holding it is lifted upward. The CONDUCTANCE LEAD and the PLATINUM DISK can be removed and replaced in situ, without disassembling the apparatus. A small fan mounted in the side of the INSTRUMENT CABINET serves to cool the top of the PROBE ASSEMBLY and the LINEAR TRANSDUCER.

-a LINEAR TRANSDUCER (1E), or Linear Variable Differential Transformer (LVDT), which works in conjunction with the LVDT READOUT (2H; located in the INSTRUMENT CABINET) to continuously measure the vertical dimension of the sample. The inner plunger of the LINEAR TRANSDUCER is attached to the STEEL ROD (5D) at the top of the PROBE ASSEMBLY. The vertical dimension, in millimeters, appears on the front panel of the LVDT READOUT. By adjusting the LINEAR TRANSDUCER HEIGHT ADJUSTMENT (1F) fixture and the controls on the front panel of the LVDT READOUT (2H), the beginning value of the vertical dimension may be set (See OPERATION Section). The LINEAR TRANSDUCER and the PROBE ASSEMBLY, which are mounted on the moveable PROBE ASSEMBLY FIXTURE (1H), can be raised (See Fig. 10) above the ash sample by loosening the uppermost hand-operated clamp on the right front shaft of the SUPPORT ASSEMBLY (1K). The upper set of weights at the rear of the SUPPORT ASSEMBLY counterbalances the weight of these components and their fixtures. When the furnace is raised (Fig. 11) and the PROBE ASSEMBLY FIXTURE is lowered, the gap at the top of the furnace is partly sealed by an insulating blanket (Fig. 10) that is sufficiently porous to allow the gas flow to be exhausted, while minimizing the loss of heat by radiation. The LINEAR TRANSDUCER and PROBE ASSEMBLY exert a combined force of approximately 0.5 kg. on the ash sample.

2.2.7 CONDUCTANCE SYSTEM

-a SIGNAL GENERATOR (2D) mounted in the INSTRUMENT CABINET, which is used to pass a current through the sample via the system of platinum wires, disks, and plates described above, and forming part of a CONDUCTANCE METER (See Figures 6 through 9). The current also passes through a set of range resistors, switched by the CONDUCTANCE SELECTOR SWITCH (2O).

-a LOCK-IN AMPLIFIER (2E) mounted in the INSTRUMENT CABINET, used to measure the current passing through the sample. The LOCK-IN AMPLIFIER is phase-locked to a reference signal from the SIGNAL GENERATOR. Any spurious, out-of-phase or out-of--frequency signals that might be caused by other equipment are rejected. The output of the LOCK-IN AMPLIFIER may be read on its front-panel meter (1 millivolt corresponds to the conductance value in microsiemens indicated by the CONDUCTANCE SELECTOR SWITCH). The conductance signal is also conditioned by a CHART RECORDER AMPLIFIER so that the conductance value in microsiemens indicated by the CONDUCTANCE SELECTOR SWITCH corresponds to five volts (0 volts corresponds to 0 microsiemens), available for recording or data-logging (see below). The CONDUCTANCE SELECTOR SWITCH may be set for each decade of conductance between 10 and 100,000 microsiemens. Proper settings for the LOCK-IN AMPLIFIER are described in the OPERATION Section.

-a PUSH TO CAL (2K) pushbutton on the front panel of the INSTRUMENT CABINET which substitutes resistors of known conductance for the ash sample. When the PUSH TO CAL button is depressed, the ash sample is removed from the conductance circuit, and a resistor of conductance equal to that marked on the CONDUCTANCE SELECTOR SWITCH is substituted for it. The meter on the LOCK-IN AMPLIFIER can then be set at full-scale by adjusting the OUTPUT AMPLITUDE knob on the SIGNAL GENERATOR (See OPERATION Section).

2.2.8 POWER CONTROL SYSTEM

-a POWER SWITCH (2B) on the front panel of the INSTRUMENT CABINET, which controls all power to the Dilation and Conductance Unit. It also serves as a 70 ampere breaker, should a current overload occur. The Dilation and Conductance unit is powered by 240 volts AC, at 60 Hz.

-a red POWER ON (2A) lamp on the front panel of the INSTRUMENT CABINET, which lights whenever the POWER SWITCH is on.

-a green OVERTEMP OK (2P) lamp on the front panel of the INSTRUMENT CABINET, which lights when a latching relay (RL1 in Figure 3) is latched ON by a push of the OVERTEMP RESET (2C) button on the front panel of the INSTRUMENT CABINET. Should the setpoint of the OVER-TEMPERATURE CONTROLLER be exceeded, the relay drops out, removing power from the RAPID TEMP FURNACE and extinguishing the OVERTEMP OK lamp. The OVERTEMP OK lamp is also extinguished when power is first applied to the Dilation and Conductance Unit by turning the POWER SWITCH on, making it necessary to push the OVERTEMP RESET button to begin a run (See OPERATION Section).

2.2.9 OTHER SYSTEMS AND FIXTURES

-an INSTRUMENT CABINET (1D), which contains most of the electronic equipment. All of the controls used during a run are on the front panel of the INSTRUMENT CABINET.

-a DESK (1C) attached to the front of the INSTRUMENT CABINET.

-four CHART RECORDER CONNECTORS (not shown in the figures), which are located on the front panel of the INSTRUMENT CABINET beneath the DESK. These are BNC connectors, all of which make available 0 to 5 volts DC signals, corresponding to CRUCIBLE TEMPERATURE (0 to 1750 degrees celsius), ELEMENT TEMPERATURE (0 to 1750 degrees celsius), CONDUCTANCE (see above) , AND DILATION (+/- 25.4 mm.).

-four VIBRATION ISOLATORS (1N) on the FLOOR LOCK (1M) assemblies of the cart, which are activated by means of foot-operated levers. The broad, flat levers activate the VIBRATION ISOLATORS and lock the cart by slightly raising it. The other, narrow, levers de-activate them.

-an ELECTRONIC INTERFACE UNIT (Figures 6 through 9), located inside the INSTRUMENT CABINET immediately behind the CONDUCTANCE SELECTOR SWITCH. The ELECTRONIC INTERFACE UNIT contains portions of the CONDUCTANCE METER circuitry as indicated in the figures, and two CHART RECORDER AMPLIFIERS, which raise the conductance and crucible temperature signals to the 0 to 5 volt range required for chart recording or data-logging.

3.0 OPERATION

CAUTION

Before turning the power on, ascertain that all parts of the instrument are in good condition and properly set up. Refer to the WARNING section at the beginning of this manual. The user should be completely familiar with the contents of this manual and with the instrument before attempting to use the Conductance and Dilatometry Unit.

3.1 PREPARATION

If the Conductance and Dilatometry Unit is to be used in an area of high vibration, activate with your foot the four VIBRATION ISOLATORS (1N) located near the wheels of the cart. A downward push on the broad lever will raise the cart and activate the isolators. Another downward push on the narrow cylindrical lever will de-activate the VIBRATION ISOLATORS.

At the beginning of every run, verify that the PLATINUM DISK (4C) and CRUCIBLE THERMOCOUPLE (4C) are properly in place in the bottom of the well that will hold the CRUCIBLE (4A) at the top of the STAND ASSEMBLY (Fig. 4), and that they are not obscured by old ash deposits. Ascertain that the CRUCIBLE THERMOCOUPLE in the middle of the well does not touch the PLATINUM DISK surrounding it. The top of the thermocouple should be approximately in the same plane as the top of the disk. Also verify that the CRUCIBLE is in good condition, that it has a square PLATINUM PLATE (4B) in place in the bottom, and that there are no melted ash deposits on it that would interfere with the measurement of conductivity. Do not fill the crucible with ash yet.

3.2 ADJUSTMENT OF GAS PRE-HEATER

Turn the POWER SWITCH (2B) on (Ref. Fig. 2-1).

CAUTION

If the gas is not to be preheated, ensure that the temperature setpoint of the GAS PRE-HEATING CONTROLLER (2I) is adjusted to zero. If you are using this instrument for the first time, and want to spend a long time adjusting the controls, set the GAS PRE-HEATING CONTROLLER to zero now, and then set it to the desired temperature just before you begin the run. The adjustment procedure is described below.

Adjust the GAS PRE-HEATING TEMPERATURE CONTROLLER (2I) as follows:

-Push the READ switch to the right.

-Turn the SET I knob, located immediately to the right of the READ switch, until the display indicates the desired gas temperature. If this represents a temperature increase, a red lamp on the GAS PRE-HEATING CONTROLLER will come on, indicating that the controller is turning on the PRE-HEATER FURNACE. If the gases are not to be pre-heated, then adjust the knob until the display indicates all zeroes.

3.3 ADJUSTMENT OF DILATOMETRY SYSTEM

Lower the RAPID TEMP FURNACE by loosening the two LOCKING CLAMPS (1J) and pushing it downward against the force of the counter-balancing weights.

Ascertain that the individual power switches on the signal generator and lock-in amplifier are ON. The red POWER ON lamp should light.

CAUTION

Do not lower the PROBE (1G) tip into the well at the top of the STAND ASSEMBLY without a CRUCIBLE (4A) in place. If a CRUCIBLE is not in place, the CRUCIBLE THERMOCOUPLE (4C) may be bent so that it touches the platinum disk surrounding it.

Now follow this procedure to set the dilation measurement to zero with the probe tip at the bottom of the empty crucible:

-Place the empty crucible in the well at the top of the STAND ASSEMBLY (Fig. 4). The crucible should fit snugly into the well, so that the wire on the bottom of the crucible makes contact with the platinum disk at the bottom of the well.

-After loosening the lever locking the PROBE ASSEMBLY FIXTURE (1H) to the round shaft on the right side of the SUPPORT ASSEMBLY (1K), gently lower the tip of the PROBE ASSEMBLY (1G) into the crucible. This is best done by holding the probe with one hand to ensure that the tip is centered in the crucible, while pushing the PROBE ASSEMBLY FIXTURE slowly down with the other hand (Ref. Fig. 10). The PROBE ASSEMBLY FIXTURE is lowered until the metal plate at its bottom (the plate that contains the ceramic ring through which the probe passes) contacts the STOP COLLAR (10A) on the left front shaft of the SUPPORT ASSEMBLY. Before the PAF reaches this point, the PROBE TIP will contact the bottom of the empty CRUCIBLE and the LINEAR TRANSDUCER body will move with respect to the STEEL ROD (5D).

-Now set the zero point of the LVDT READOUT (2H) and LINEAR TRANSDUCER (1E) combination. Ascertain that the screwdriver zero adjustment on the front of the LVDT READOUT is near the middle of its range. The zero adjustment screw has a range of twelve turns without end stops. It may be centered by turning it until the meter reading stops changing, then turning it back by six turns. If zero occurs near this center point, then set the readout to zero using the zero adjust screw. If not, then set the zero point mechanically by moving the LINEAR TRANSDUCER up or down as shown in Figure 12, "Linear Transducer Height Adjustment." After setting the zero mechanically, use the screwdriver adjustment on the LVDT READOUT to refine the adjustment. Lift the probe assembly and lower it again onto the bottom of the empty crucible. The LVDT should again read zero.

Fill the CRUCIBLE with a sample of ash and place it in the STAND ASSEMBLY (Fig. 4). The crucible should fit snugly into the well, so that the wire on the bottom of the crucible makes contact with the platinum disk at the bottom of the well. Mass, volume and degree of compaction of the sample are to be determined by the experimenter. The default condition is to fill the crucible to the top with lightly compacted ash. The end of a metal rod can be used to compact the sample, if so desired.
You may wish to weigh the sample.

Gently lower the tip of the PROBE ASSEMBLY onto the sample, following the procedure described above, remembering to hold the probe with one hand to assure that the tip is centered in the crucible. As before, the probe assembly fixture is lowered until the metal plate contacts the stop collar on the left shaft.

Ascertain that the steel LOCKING COLLAR (Fig. 12) on the ceramic probe is positioned a suitable distance above the ceramic collar through which the probe passes. It is this dimension that determines the maximum amount the probe will drop as the ash sample sinters. During initial trials a distance of 5 mm. was used. The LOCKING COLLAR also prevents the probe from dropping too far, when the PROBE ASSEMBLY fixture is raised. The steel LOCKING COLLAR is held by an Allen set screw. When adjusting the collar, use minimum torque on the screw to avoid cracking the probe.

The LVDT READOUT reading, which now corresponds to the height of the ash sample, should be in the 8 to 13 mm range when the probe is resting on a sample of ash that nearly fills the crucible. This dimension depends, of course, on the degree of compaction and the type of material.

Set the LVDT READOUT value at which the main furnace will trip out, by turning the "Set Low Limit" screwdriver adjustments (the two adjustment screws are for coarse and fine) on the LVDT READOUT (2H) while depressing the pushbutton nearest them. (A value of one millimeter less than the height of the ash has been used in trial runs. The actual setting will depend on the nature of the experiment and the characteristics of the ash. The objective is to obtain meaningful changes in dilation and conductance without melting the ash to the point that the crucible adheres to the probe tip.

Depress the button near the "Set High Limit" screwdriver adjustments. Ensure that the reading is very high (e.g. 40 mm.). This will prevent the high limit from having any effect on the run.

Raise the RAPID TEMP FURNACE chamber over the sample (See Fig. 11) until the top of the furnace assembly contacts the locking collar located on the leftmost front shaft of the SUPPORT ASSEMBLY (1K). Lock it in place with both LOCKING CLAMPS (1J).

Ensure that the insulating pads (Fig. 10) or their equivalent are in place where the probe enters the furnace.

3.4 ADJUSTMENT OF CONDUCTANCE SYSTEM

Set the SIGNAL GENERATOR (2D) to:

-FREQUENCY DIAL: 1.0.
-POWER: ON (Pushbutton IN).
-FREQUENCY MULTIPLIER: 1K.
-MODE: CONTINUOUS (All three buttons OUT).
-FUNCTION: Sinewave.
-DC OFFSET: OFF.
-AMPLITUDE: approximately 9 O'clock.

Set the LOCK-IN AMPLIFIER (2E) as follows:

-SENSITIVITY: 1 mV.
-OFFSET: OFF (Both pushbuttons OUT).
-ZERO: Does not matter (Switched out).
-TIME-CONSTANT (PREFILTER): 0.1 Seconds.
-POST FILTER: OFF (Both pushbuttons OUT).
-QUADRANT: 90 + 180 (Both pushbuttons IN).
-MODE: "f" (Pushbutton OUT).
-PHASE adjustment: 0 degrees.

Set the CONDUCTANCE SELECTOR SWITCH (2O) to the desired range. (The 1000 microsiemen range has been used on some initial trials.) Final setting will depend on the characteristics of the sample and on the design of the experiment.

While pressing the PUSH TO CAL (2K) button, ascertain that the PHASE adjustment on the LOCK-IN AMPLIFIER is set for a maximum reading on the LOCK-IN AMPLIFIER meter. This is done by moving the PHASE adjustment knob back and forth a few degrees while observing the meter. While still pressing the PUSH TO CAL button, adjust the SIGNAL GENERATOR OUTPUT AMPLITUDE for a full-scale reading on the LOCK-IN AMPLIFIER meter. When the PUSH TO CAL button is released, the CONDUCTANCE METER circuit will be reading the calibrated conductance of the sample. Normally, this will be zero for unheated samples. For maximum accuracy, if the setting of the CONDUCTANCE SELECTOR SWITCH is changed during a run, repeat the above calibration step, omitting the check of PHASE.

3.5 ADJUSTMENT OF OVER-TEMPERATURE CONTROLLER

Adjust the setpoint of the OVER-TEMPERATURE CONTROLLER (2J) to a value approximately 200 degrees above any temperatures expected in the run. If for any reason (e.g. thermocouple failure) the RAPID TEMP FURNACE (2F) should exceed this value, it will be shut off.

CAUTION

It is important to use the OVER-TEMPERATURE CONTROLLER to protect the equipment in case of a failure of the MAIN TEMPERATURE CONTROLLER. Furthermore, the RAPID TEMP FURNACE will not heat up if the OVER-TEMPERATURE CONTROLLER is not first set properly as described below.

Set the OVER-TEMPERATURE CONTROLLER (2J) in the following manner:

-If the green "MAN" (manual) lettering on the display is illuminated, Push the START/STOP key to remove it.

-Use the PARAM/DISPLAY key to make the lower part of the display read "SP ___" (SP means SETPOINT).

-Use the UP(Arrow)/YES and DOWN(Arrow)/NO keys to move the SP value to the desired temperature in degrees celsius. The setpoint should be approximately 200 degrees above any temperatures expected in the run. The OVER-TEMPERATURE CONTROLLER uses a different thermocouple than does the MAIN TEMPERATURE CONTROLLER, and may read a different temperature. Do not set the setpoint too low, or the run may be aborted early.

3.6 ADJUSTMENT OF MAIN TEMPERATURE CONTROLLER

Verify that the MAIN TEMPERATURE CONTROLLER (2F) has the desired program stored in memory. Before attempting to write or modify a program, the user should be familiar with the operation of this controller. As an example, the programming segment required to produce a linear ramp in temperature from 40 to 1300 degrees Celsius at 6 degrees per minute follows:

-Flip down the Operator Panel to expose the Primary Panel.

-Place the controller in manual mode by pressing the MANUAL/AUTO Key.

-Place lower display in programmer tables by pressing PGMR TABLES key.

-To obtain full access, press the RI logo and then the hidden dey beside the up/down arrows on the upper display.

-If the lower display is not reading "SEGMENT" (indicated by SEGMENT light), then select it by using the SCROLL (arrow) keys to the left of the connector on the lower display section.

-Select starting segment. For this example, segment 1 is selected. This is done by using the up/down keys located immediately above the connector, on the command entry section.

-Next scroll down to "SETPOINT" using the arrow keys to the left of the connector. The ENTER key will light up. Press ENTER and the light will go out and the lights in the up/down scroll keys will light up. Use the command entry arrow keys to scroll up to the maximum temperature in degrees Celsius desired, and press ENTER again. For this example, the maximum temperature is 1300 degrees. Since this is segment 1, the starting temperature will be the minimum control temperature, which is 40 degrees.

-Since no events are required, scroll to "SEGMENT TIME" and select the length of time you want the furnace to take to reach this temperature. For a temperature change of 1260 (1300 - 40) degrees and a rate of temperature increase of 6 degrees per minute, this would be 3 hours and 30 minutes. Press the ENTER key, and if the first two numbers on the lower display flash on and off, the scroll keys are enabled. The first two numbers are hours, the second two numbers are minutes, and the third two are seconds. By using the scroll keys, set the hours indication to 3. Press ENTER again and the minutes flash; scroll to 30. Press ENTER again and the seconds flash; scroll to 0. Press ENTER a final time and all numbers will be stable.

-Since this program will not be recycled, scroll to the next segment. Since this is a single segment program, scroll to segment 1 to end the run. This will ramp the furnace up to 1300 degrees in 3.5 hours, or 6 degrees per minute. When it reaches temperature it will maintain it until the operator turns it off.

-Close the Operator Panel to preserve the program and prevent changes by unauthorized personnel.

CAUTION

In order to operate, the PRE-HEATER FURNACE must receive a signal from the MAIN TEMPERATURE CONTROLLER. For every program segment in which it is desired to preheat the gases, EVENT 1 must be programmed ON in the MAIN TEMPERATURE CONTROLLER.

Once the MAIN TEMPERATURE CONTROLLER is properly programmed, press its HOLD/RUN key:

-The segment number should flash.
-The RUN indicator should flash.
-The ENTER key should light.
-The UP/DOWN arrows should light.

3.7 CONNECTION OF CHART RECORDER OR DATA-LOGGER

Connect a data-logger or chart recorder to the BNC connectors on the front panel of the INSTRUMENT CABINET (1D) below the DESK (1C). The normal process variables to be recorded are CRUCIBLE TEMPERATURE, CONDUCTANCE, and DILATION. FURNACE (element) TEMPERATURE is also available for recording, but will not be equal to the crucible temperature at all times. It will of course tend to lead (in time) the CRUCIBLE TEMPERATURE.

Carefully set the controls on the datalogger or chart recorder. The temperature and conductance channels will be at zero. The DILATION channel will read the height of the ash sample (typically 8 to 13 mm.). All outputs are 0 to 5 volts. Refer to the SPECIFICATIONS section to interpret these voltages in terms of units that refer to the process variables.

3.8 ADJUSTMENT OF GAS SYSTEM

If a gas flow is to be used, open the appropriate TWO STAGE REGULATOR (1B) and the AUXILIARY SHUTOFF VALVE (mounted slightly downstream of the regulator), and adjust the pressure to 15 psi.

CAUTION

Do not set the air and or nitrogen pressures above 15 psi. Overpressure could exceed the capacity of the tygon tubing used to distribute the gases in the Unit.

Use the panel-mounted FLOW VALVE (2M, 2N) marked for the gas in use, to control the flow, reading the flow on the FLOWMETER (2L). Refer to the DESCRIPTION Section for an explanation of the two floats in the FLOWMETER.

If you had temporarily set the GAS PRE-HEATING TEMPERATURE CONTROLLER to zero and wish to pre-heat the gases, follow the previously-described procedure to adjust its setpoint.

CAUTION

In order to operate, the PRE-HEATER FURNACE must receive a signal from the MAIN TEMPERATURE CONTROLLER. For every program segment that it is desired to preheat the gases, EVENT 1 must be programmed ON in the MAIN TEMPERATURE CONTROLLER.

3.9 EXECUTION OF MEASUREMENT

Start the run by pushing the OVERTEMP RESET (2C) button. The green OVERTEMP OK (2P) lamp will be illuminated and the run should begin. Verify that the run is proceeding properly, by watching the CRUCIBLE TEMPERATURE READOUT (2G) and the PROCESS VARIABLE (crucible temperature) as indicated on the MAIN TEMPERATURE CONTROLLER (2F), to ascertain that the temperatures of the crucible and elements are both indicated and rising. It will take a few minutes for the readings to change.

During the run, check the instruments frequently to ascertain that all is well. Refer to the APPENDIX for a chart recording of a typical run.

3.10 REMOVAL OF SAMPLE

When the instrument has cooled sufficiently to safely remove the sample, lower the RAPID TEMP FURNACE and carefully raise the PROBE ASSEMBLY fixture. Use caution to avoid damage to the refractories or the platinum parts, should the ash have melted sufficiently to adhere the various parts together. If the instrument was programmed so that cooling began soon enough, the sample will only have sintered, making it possible to remove the CRUCIBLE by hand.

If the PLATINUM DISK (5A) at the PROBE tip adheres to the top of the ash, it is still possible to pull (with care) the CRUCIBLE downward a centimeter or two, pulling the CONDUCTANCE LEAD (5C) and PLATINUM DISK (5A) along with it. Carefully pull the CRUCIBLE down enough to insert a sharp, curved pin-tool under the edge of the PLATINUM DISK so that it may be pried out. Remove all excess sintered ash from the instrument by carefully scraping it off with a knife or the like. When scraping the PLATINUM DISK (5A), hold it carefully to avoid damage to the CONDUCTANCE LEAD near its weld to the disk.

If it is impossible to remove the CRUCIBLE by hand, it may be heated with an oxy-acetylene torch to re-melt the ash. This procedure will destroy the crucible, but it is possible to recover the square PLATINUM PLATE from the bottom. If the ash has thoroughly melted, the tip of the PROBE will have to be ground on a belt sander or grinding wheel. Support it carefully to avoid shear forces on the alumina tip.

4.0 MAINTENANCE

CAUTION

Ensure that no power reaches the Conductance and Dilatometry Unit when performing maintenance. For complete safety, it is recommended that the power be shut off at a breaker box external to the machine. Do not operate the Unit if any electrical equipment is not in good condition.

Refer to the vendor literature in the APPENDIX for maintenance instructions for the individual pieces of equipment.

The Parts Lists in the APPENDIX are keyed to the main assembly drawings, also in the APPENDIX.

The CRUCIBLE THERMOCOUPLE (4A, 4J) and CONDUCTANCE LEAD (4I) in the STAND ASSEMBLY can be replaced by following this procedure:

-Disconnect any leads to be replaced where they attach to a terminal strip in the lower part of the CART immediately under the STAND ASSEMBLY.

-Slowly pull the lead or leads upward from the top of the STAND ASSEMBLY, exercising extreme care.

-Carefully straighten any new lead or leads.

-Slowly insert the new lead or leads into the appropriate PROTECTION SLEEVE at the top of the STAND ASSEMBLY. There are two holes in the PROTECTION SLEEVE for the CONDUCTANCE LEAD. Either one may be used. Exercise extreme caution so as not to break the thermocouple leads or lodge a bent lead in a protection sleeve.

-Carefully re-connect the leads at the terminal strip.

The CONDUCTANCE LEAD in the PROBE ASSEMBLY can be replaced by pulling out the old lead and carefully pushing in a new one. If difficulty is experienced, it is possible to insert this one by first inserting a small stainless steel "fish wire" and pulling the new lead through.

The CONDUCTANCE LEADs are attached to their platinum disks by welding. The preferred method is laser welding.

The two thermocouples at the side of the RAPID TEMP FURNACE can easily be replaced. They are simply pushed into place through close-fitting holes and held by their connections to the terminal strips.
It is possible to adjust the reading of the OVER-TEMPERATURE CONTROLLER to closely match the reading of the element temperature on the MAIN TEMPERATURE CONTROLLER by moving the frontmost thermocouple at the side of the RAPID TEMP FURNACE a short distance in and out with the furnace controlling to a setpoint, until the two readouts agree.

It is advisable to check the operation of the CONDUCTANCE CHANNEL occasionally, by connecting a resistor between the two platinum disks associated with the measurement of conductance. This is easily done with small clip leads, and will detect any broken wires or loose connections external to the ELECTRONIC INTERFACE UNIT. On the 1000 microsiemen scale, a 10,000 ohm, 1 percent resistor should produce a full-scale reading.

It is possible to verify the electrical calibration of the LVDT READOUT by pushing the CAL BUTTON on its front panel. The digital readout should indicate 26.40, indicating that the unit responds properly to a fixed test signal. The value of 26.40 was obtained during the last calibration of the system. If 26.40 is not indicated, or if any inaccuracy is suspected on other grounds, then the dilation channel should be calibrated by moving the probe assembly a known distance and adjusting the SPAN screwdriver adjustments (coarse and fine) on the front panel of the LVDT READOUT until the meter reads the same distance in millimeters.

5.0 SPECIFICATIONS

5.1 CONDUCTANCE CHANNEL

RANGES: When the LOCK-IN AMPLIFIER is set up as specified in the OPERATION Section, 0 to 1 mV (full scale on its upper meter scale) will correspond to 0 to X, where X is the value in microsiemens to which the CONDUCTANCE SELECTOR SWITCH is set. The switch has ranges of 0 to 10, 0 to 100, 0 to 1000, 0 to 10,000, and 0 to 100,000 microsiemens.

ACCURACY: +/- 1.5 %, all ranges.

VOLTAGE APPLIED TO SAMPLE: Approximately 100 mV., at 1000 Hz. The SIGNAL GENERATOR and LOCK-IN AMPLIFIER may be re-set to apply other voltages and frequencies to the sample.

RECORDER OUTPUT (BNC connector below DESK): 0 to 5 VDC, corresponding to full selected conductance range; source impedance of less than 100 ohms.

5.2 DILATION CHANNEL

RANGE: +/- 25.4 mm, indicated directly in millimeters on front panel of LVDT READOUT. The range may be changed by means of internal dip-switches. Refer to the manual for the LVDT READOUT.

WEIGHT APPLIED TO SAMPLE BY PROBE ASSEMBLY, INCLUDING LVDT ROD: Approximately 0.5 kg.

RECORDER OUTPUT (BNC connector below DESK): +/- 2.54 VDC, corresponding to full dilation range; source impedance of less than 100 ohms.

5.3 CRUCIBLE TEMPERATURE CHANNEL

THERMOCOUPLE: Type S.

RANGE: 0 TO 1750 deg. C., indicated on front panel of CRUCIBLE TEMPERATURE READOUT.

ACCURACY: +/- 2.3 deg. from 335 to 1750 deg. C.

RECORDER OUTPUT (BNC connector below DESK): 0 to 5 VDC, corresponding to 0 TO 1750 deg. C.; source impedance of less than 100 ohms.

RESPONSE TO CONTROL: See the APPENDIX for a chart recording showing the response of the crucible temperature channel to programmed heating and cooling ramps.

5.4 RAPID TEMP FURNACE CHANNEL (ELEMENT TEMPERATURE).

THERMOCOUPLE: Type B.

RANGE OF CONTROLLER AND READOUT: 0 to 1820 deg. C., as indicated by PROCESS VARIABLE on front panel of MAIN TEMPERATURE CONTROLLER.

RECOMMENDED FURNACE RANGE: 1600 deg. C. continuous; 1700 deg. C. for short runs. Refer to manual for RAPID TEMP FURNACE.

MAXIMUM RATE OF TEMPERATURE INCREASE: Exceeds 20 deg. C/min.

PRECISION OF STEADY-STATE CONTROL: +/- 1 deg. C.

RECORDER OUTPUT (BNC connector below DESK): 0 to 5 VDC, corresponding to 0 to 1750 deg. C.; source impedance less than 100 ohms.

OVERTEMPERATURE PROTECTION: By means of separate controller and type B thermocouple, with setpoint adjustable up to 1820 deg. C.

5.5 GAS DELIVERY SYSTEM

NITROGEN FLOW RANGE: 0 to 0.846 L/min. (Stainless steel float); 0 to 0.384 L/min. (Glass float).

AIR FLOW RANGE: 0 to 0.832 L/min. (Stainless steel float); 0 to 0.378 L/min. (Glass float).

PRE-HEATER TEMPERATURE RANGE: 0 TO 980 deg. C.

5.6 SAMPLE CRUCIBLE

DIMENSIONS: 7.8 mm inside diameter, 14 mm inside depth.

MATERIAL: Alumina.

5.7 POWER SUPPLY

240 VAC, 60 Hz., 70 Amps.

5.8 NOMINAL DIMENSIONS

110 cm. long by 62.2 cm. wide (plus 45.7 cm for desk) by 206 cm. high.

6.0 APPENDIX

INCLUDED WITH ALL COPIES OF THIS MANUAL:

CALIBRATION OF CRUCIBLE TEMPERATURE READOUT (TABLE AND GRAPH)
CHART RECORDING OF TYPICAL RUN
CHART RECORDING OF TEMPERATURE RAMP TEST
TABLE OF FUNCTION PARAMETERS FOR MAIN TEMPERATURE CONTROLLER
PARTS LISTS
DATA SHEETS FOR FM4333 FLOWMETER
DATA SHEETS FOR EVERETT CHARLES LVDT 1000 GPD
DATA SHEETS FOR MARCUS TRANSFORMER 10224-586

INCLUDED WITH MASTER COPY OF THIS MANUAL ONLY:

MANUALS FOR INDIVIDUAL COMPONENTS:

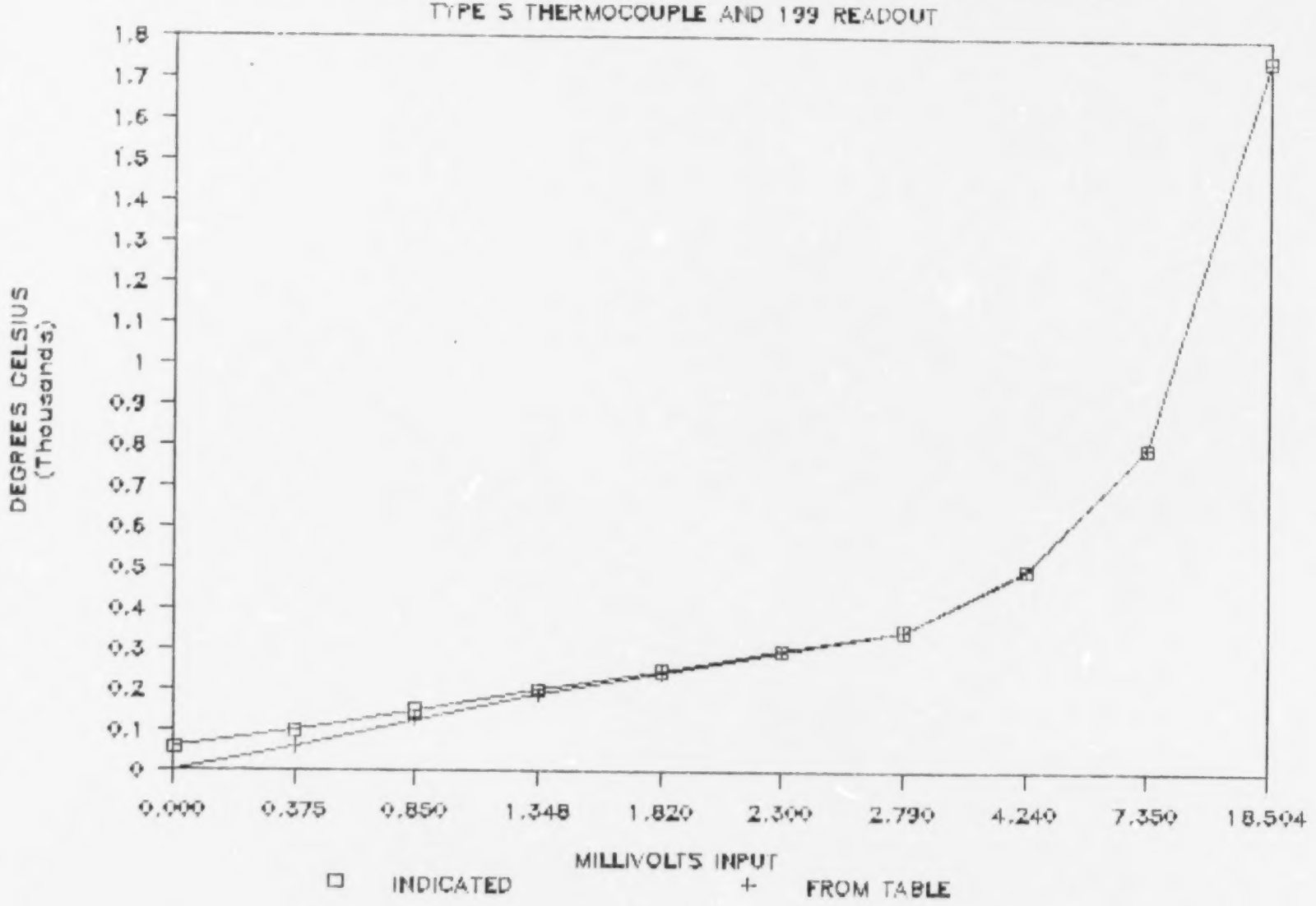
-MAIN TEMPERATURE CONTROLLER: Micristar 828D (User Manual and Operational Guide).
-LVDT READOUT: Daytronic 3330 (Three related manuals: 3300 Hi/Lo, 3200/3300 Dig. Ind., and 3130 LVDT Cond.).
-GAS PREHEATING TEMP. CONTROLLER: Omega 4000 KC Operator's Manual.
-OVER-TEMP. CONTROLLER: Omega CN-2000 Operator's Manual.
-CRUCIBLE TEMP. READOUT: Omega 199 Operator's Manual.
-SIGNAL GENERATOR: Wavetek 182A Instruction Manual.
-LOCK-IN AMPLIFIER: EG&G 5101 Lock-In Amplifier Operating and Service Manual.
-RAPID TEMP FURNACE: Synergetic Tech 1700S-VTF Manual, including drawings.
-GAS PRE-HEATER FURNACE: Thermolyne F21125 Owner's Manual.

MECHANICAL DRAWINGS (2 SETS).

CALIBRATION OF CRUCIBLE TEMPERATURE READOUT (OMEGA 199)
FOR USE WITH S TYPE THERMOCOUPLE
MAR. 20. 1987

INDICATED TEMPERATURE DEGREES C.	MILLIVOLTS INPUT	TEMPERATURE FROM T/C TABLE	VOLTS OUT TO RECORDER
61	0.000	0	0.173
100	0.375	62	0.286
150	0.850	127	0.428
200	1.348	189	0.569
250	1.820	244	0.713
300	2.300	298	0.855
350	2.790	351	1.000
500	4.240	501	1.428
800	7.350	801	2.283
1750	18.504	1750	4.990

CALIBRATION OF CRUCIBLE TEMP. READOUT



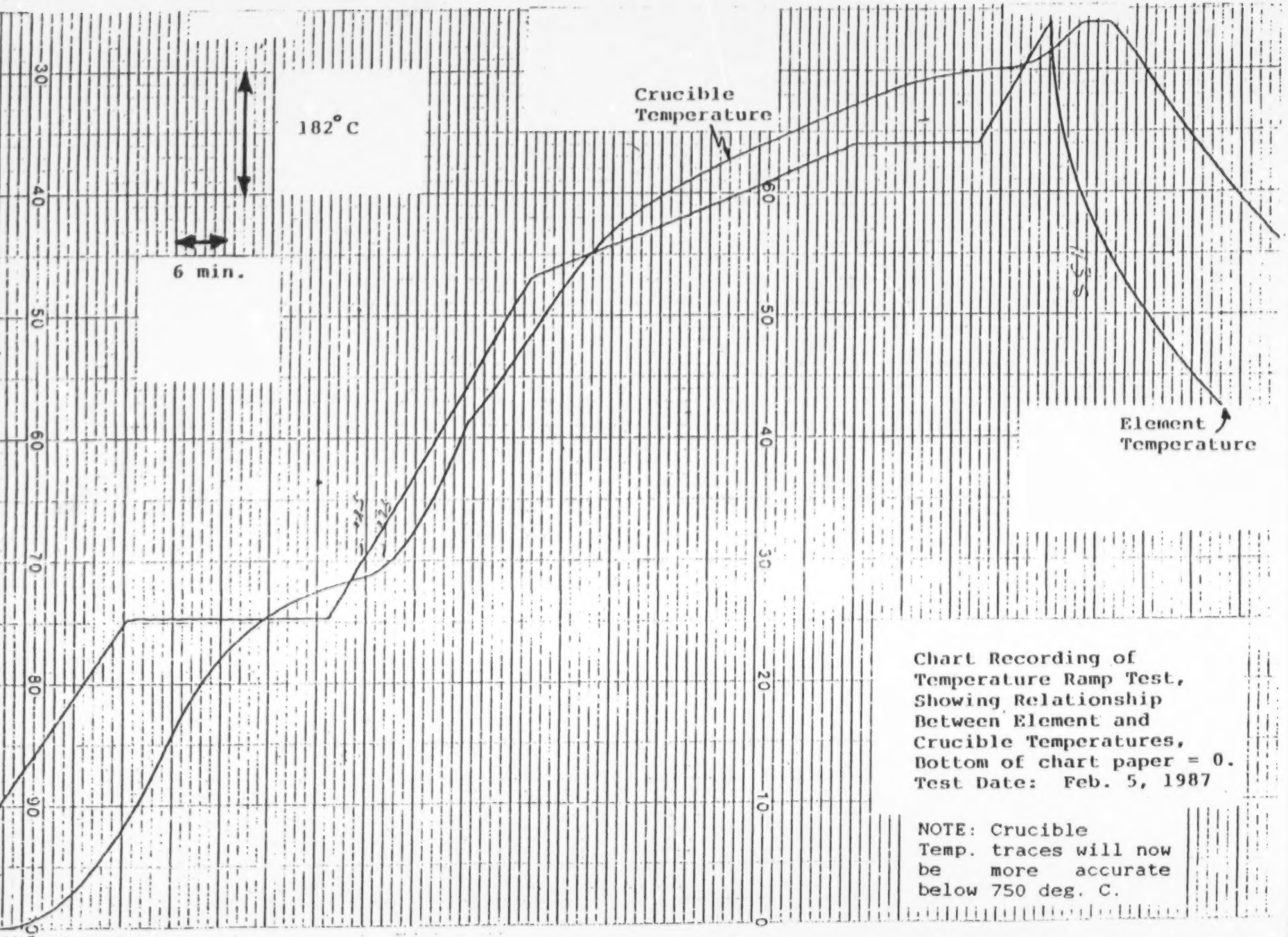
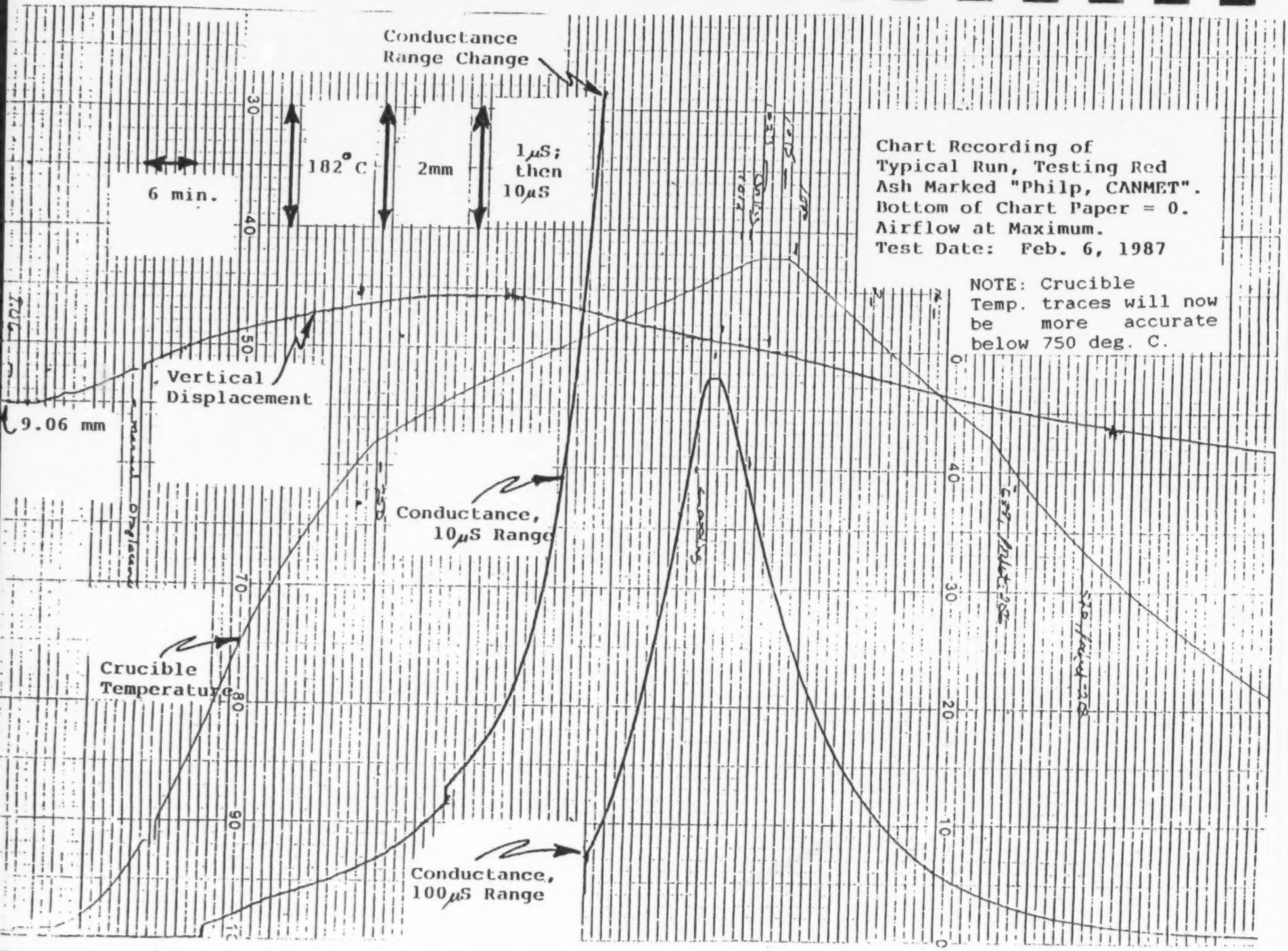


Chart Recording of Temperature Ramp Test, Showing Relationship Between Element and Crucible Temperatures, Bottom of chart paper = 0.
Test Date: Feb. 5, 1987

NOTE: Crucible Temp. traces will now be more accurate below 750 deg. C.


Conductance
Range Change
6 min.
182° C
2mm
1μS;
then
10μS
Vertical
Displacement
9.06 mm
Conductance,
10μS Range
Crucible
Temperature
Conductance,
100μS Range
Chart Recording of
Typical Run, Testing Red
Ash Marked "Philp, CANMET".
Bottom of Chart Paper = 0.
Airflow at Maximum.
Test Date: Feb. 6, 1987
NOTE: Crucible
Temp. traces will now
be more accurate
below 750 deg. C.

FUNCTION CODE	DESCRIPTION	PARAMETER TABLE	PARAMETER VALUE
CF - 1	Process Variable Units	2-2	C
CF - 2	Range Cartridge	2-2	521
CF - 3	Linear Range Decimal Alignment	2-2	0.0
CF - 4	Linear Range Minumum Value	2-3	0.0
CF - 5	Linear Range Maximum Value	2-4	1600.0
CF - 11	Setpoint Minimum	2-6	40
CF - 12	Setpoint Maximum	2-6	1600
CF - 13	Output Action	2-6	r
CF - 14	Reset Action	2-5	1
CF - 15	Direct Output High Limit	2-6	100
CF - 16	Direct Output Low Limit	2-6	0.0
CF - 17	Reverse Output High Limit	2-6	100
CF - 18	Reverse Output Low Limit	2-6	0.0
CF - 19	(Factory Setting)		500.0
CF - 30	OS Alarm - Controller Response	2-7	OFF
CF - 31	OS Alarm - Alarm Response	2-7	L
CF - 32	HI-PV Alarm - Alarm Response	2-7	L
CF - 33	LO-PV Alarm - Alarm Response	2-7	L
CF - 34	HI-DEV Alarm - Alarm Response	2-7	L
CF - 35	LO-DEV Alarm - Alarm Response	2-7	L
CF - 41	OS Alarm Relay Drive Output	2-8	0
CF - 42	HI-PV Alarm Relay Drive Output	2-8	0
CF - 43	LO-PV Alarm Relay Drive Output	2-8	0
CF - 44	HI-DEV Alarm Relay Drive Output	2-8	0
CF - 45	LO-DEV Alarm Relay Drive Output	2-8	0
CF - 51	EVENT 1 Relay Drive Output	2-8	1
CF - 52	EVENT 2 Relay Drive Output	2-8	0
CF - 53	EVENT 3 Relay Drive Output	2-8	0
CF - 54	EVENT 4 Relay Drive Output	2-8	0
CF - 55	EVENT 5 Relay Drive Output	2-8	0
CF - 56	EVENT 6 Relay Drive Output	2-8	0
CF - 57	EVENT 7 Relay Drive Output	2-8	0
CF - 58	EVENT 8 Relay Drive Output	2-8	0
CF - 61	Source for Analog Output #1	2-12	3
CF - 62	Source for Analog Output #2	2-12	0
CF - 63	Source for Analog Output #3	2-12	0
CF - 64	Source for Analog Output #4	2-12	0
CF - 65	Source for T/P Output #1	2-14	2
CF - 66	Cycle Time for T/P Output #1	2-13	1.6
CF - 67	Source for T/P Output #2	2-14	0
CF - 68	Cycle Time for T/P Output #2	2-13	6.4
CF - 71	Line Frequency Identification*	2-15	60
CF - 101	On-site PV Calibration	2-16	1750
CF - 102	Factory PV Calibration Step #1	2-16	17138
CF - 103	Factory PV Calibration Step #2	2-16	138
CF - 104	Factory PV Calibration Step #3	2-16	-1931
CF - 105	Factory PV Calibration Step #4	2-16	6666
CF - 106	Factory PV Calibration Step #5	2-16	0
CF - 107	On-site Cold Junction Gain	2-16	)not accessable
CF - 108	Factory Cold Junction Gain	2-16	)when configured
CF - 109	On-site Cold Junction Offset	2-16	)for type B + C
CF - 110	Factory Cold Junction Offset	2-16	)type B uses no)cold junction)compensation.
CF - 111	Analog Output #1 - DC OFFSET	2-17	99
CF - 112	Analog Output #1 - GAIN	2-17	1030
CF - 113	Analog Output #2 - DC OFFSET	2-17	103
CF - 114	Analog Output #2 - GAIN	2-17	980
CF - 115	Analog Output #3 - DC OFFSET	2-17	106
CF - 116	Analog Output #3 - GAIN	2-17	980
CF - 117	Analog Output #4 - DC OFFSET	2-17	108
CF - 118	Analog Output #5 - GAIN	2-17	985

Table of Function Parameters for
Main Temperature Controller

List of components and material required for conductance and dilatometry unit.

		Quantity
A.	Base Frame	
1.	Frame (1 x 1 steel tubing)	
2.	Swivel casters - REVVO Cat. No. TS3 125 HRP3	4
3.	Rapistan Floor Locks - J-B- REID Cat. No. FL44	4
4.	Anti-vibration mount - SPAE-NAUR Cat. No. 314-056	4
B.	Rig Assembly	
1.	Guiding bars (1.00 dia. steel bars)	2
2.	Plates (steel)	2
3.	Spacers (.75 Dia. steel bars)	2
4.	Plate (aluminum	1
5.	Spacers (.622 Dia. steel bars)	2
6.	Plate (steel)	1
7.	Plate (aluminum)	1
8.	Brackets (2 x 2 angles)	4
9.	Supporting bars (.75 Dia. steel bars)	2
10.	Supporting plate	1
11.	Weight plate	11
12.	Bushing (alumina)	1
13.	Idler sprockets - DODGE Cat. No. 320H	8
14.	Bushing (Teflon)	1
15.	Linear ball bushing THOMSON Cat. No. A-162536	2
16.	Linear ball bushing THOMSON Cat. No. A-162536	2
17.	LVDT Holder (aluminum and steel bars)	1
18.	Roller chain No. 35	4
19.	Weight plate	4
20.	supporting Plate	1
21.	Rod	2
22.	Rod	2
23.	Bushing	2
24.	Coupling	1
25.	Rod	2
26.	Bracket	2

C. Probe Assembly

1.	Probe (1.00 Dia. & .25 Dia. alumina tubes + alumina cement)	1
2.	Crucible support (2.25 Dia. alumina tube + alumina cement)	1
3.	Heat shield (alumina)	1
4.	Rapid temp. furnace 1700S VTF C.M. Inc.	1
5.	Alumina crucible 10 mm O.D., 8 mm I.D., 12 mm h	20

D. Gas Preheating Unit

1.	Two-stage regulators - UNION CARBIDE Part No. TSA-15-CGA-580	2
2.	Ultra-fine metering valves - UNION CARBIDE Part No. SG-5340-3	2
3.	Rotameter - UNION CARBIDE 7200 Series Tube No. 203 0.2-2.0SLMP	1
4.	High pressure cylinders Q size	2
5.	Thermolyne tube furnace - FISHER SCIENTIFIC Part No. 10-559-10	1
6.	Clamp holder - UNION CARBIDE Part No. SG-6203	4
7.	Misc. components (Tygon and stainless steel tubes)	

E. Instrument Rack

1.	Economy rack - HAMMOND MFTG. Cat. No. REFK1904224	1
2.	Rack mounted desk - HAMMOND MFTG. Cat No. RSAD1900117SD4	1
3.	Blank rack panel - HAMMOND MFTG. Cat. No. PBPS19010	1
4.	Blank rack panel - HAMMOND MFTG. Cat. No. PBPS19007	1
5.	Blank rack panel - HAMMOND MFTG. Cat. No. PBPS19008	1
6.	Misc. hardware components	
7.	Full height door RSDL19042	1

F. Instruments

1.	Micristar process controller Model 8280	1
2.	Controller - Omega Model 2001-BC	1
3.	Indicator/controller - DAYTRONIC Model 3130 with internal relay option and calibration of systems	1
4.	L.V.D.T. - SCHAEWITZ Model 1000 HR	1
5.	Phase lock amplifier	1
6.	Wavetek Function Generator	1
7.	Misc. electrical components	
8.	Transformer 240-100 UNION ELECTRIC	1
9.	Controller - Omega Model 4001KC	1
10.	Controller - Omega Model 199	1
11.	Push to cal switch	1
12.	Overtemp reset switch	1
13.	Power on light (red)	1
14.	Power switch	1
15.	Overtemp ok light (green)	1
16.	Conductance selector switch	1
17.	Crucible temp outlet	1
18.	Furnace temp outlet	1
19.	Conductance outlet	1
20.	Dilation outlet	1

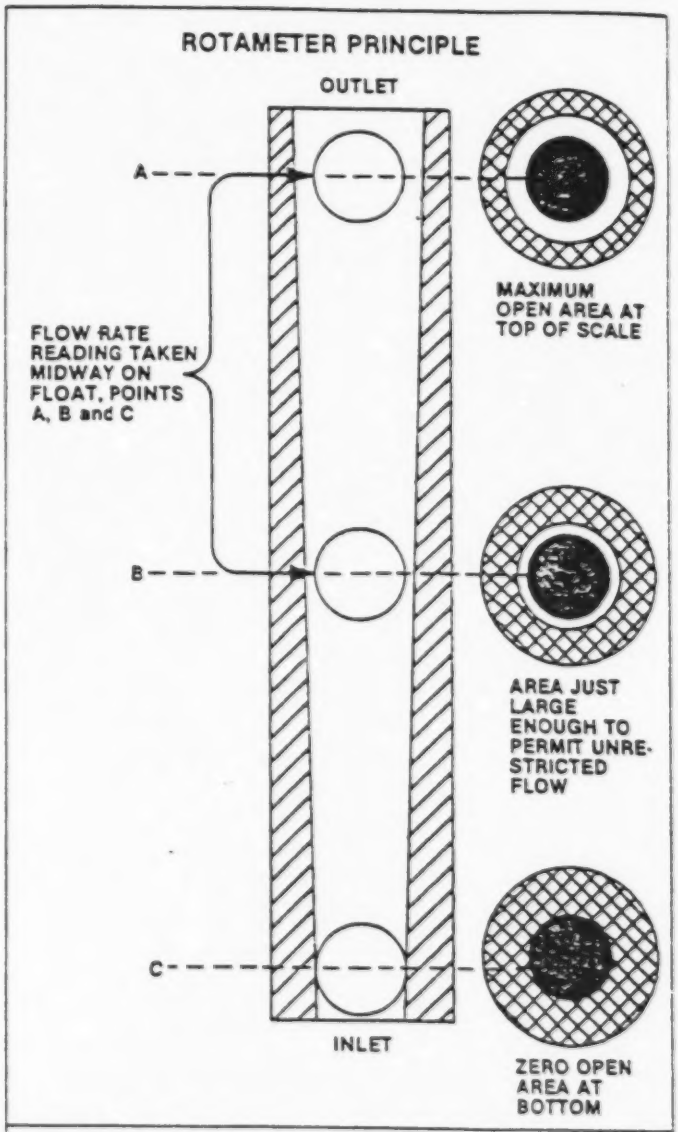
Flowmeters

Flowmeters are devices for *measuring* the flow of liquids or gases. Unless equipped with a metering valve, they do not *control* flow rate. Linde supplies two types of flowmeters.

1. *The Rotameter or Glass Tube-Variable Area Meter.* This consists of a precision-tapered glass tube with one or more spherical floats. As the gas or liquid enters the tube, the float rises to a point at which the area between the tube wall and the float is large enough to permit unrestricted flow. The greater the flow rate, the higher the float rises. Because the height of the float is proportional to the flow rate, the tube can be calibrated in flow rate values.

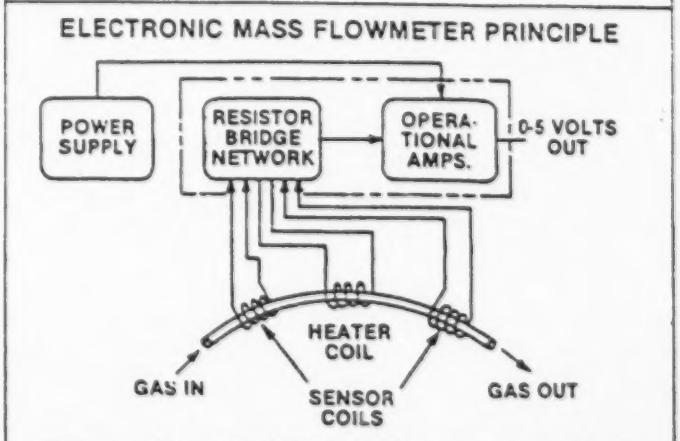
Floats of several different densities are available in some Linde Flowmeters. Lighter floats rise higher in a given gas or liquid than denser floats and the range of a flowmeter can be greatly varied by using different floats. Each standard flowmeter tube has two floats, one of stainless steel and one of borosilicate glass, thus providing two flow ranges. Calibration charts for air and nitrogen at 70°F (21°C) and 14.7 psia (101 kPa abs.) are supplied with each flowmeter assembly or tube ordered.

Temperature and pressure affect glass tube flowmeters. Flowmeter tubes can be calibrated at any temperature or pressure within their operating limits, but these conditions must be maintained for readings to be valid. A regulator should always be used to control flowmeter inlet pressure so that readings will be consistently accurate.



2. *Electronic Mass Flowmeter.* These instruments utilize the principle that the true mass flow rate of a gas is a function of the thermal properties of the gas and its temperature rises when a small, measured quantity of heat is applied to the gas. Unlike with glass tube flowmeters, flow rate readings are unaffected by gas pressure or temperature changes within specific ranges. The electronic mass flow *controller* is a mass flowmeter incorporating a valve that, on signal from the flow sensor, corrects the flow to a preset rate.

Linde now offers a multi-channel combination electronic mass flowmeter and flow controller system, having a single readout box, that can serve either or both functions. This system can also be used to blend two, three or four gas streams in an infinite number of precise ratios. A detailed description of the Multiple Channel Mass Flowmeter-Flow Controller may be found on page 41.



The gas to be measured flows through a sensor tube. The difference in "readings" of the two resistance thermometers is in direct, linear proportion to the mass flow, which is displayed separately.

GENERAL PURPOSE FLOWMETERS

Series 150 flowmeters offer an accurate yet economical means of measuring gas or liquid flow at low pressures and at rates over a wide range. They are suitable for both plant and laboratory and are widely used in gas chromatography, atomic absorption studies and in the electronic crystal growing industry.

Two models are available: the single tube model (FM4300 through FM4312) for monitoring one gas stream; and the four tube model (FM4600 through FM4612) which has four flowmeter tubes in a single housing, permitting up to four separate streams to be monitored simultaneously. Separate inlet and outlet fittings are provided for each tube. All Series 150 flowmeters are available in three configurations: without metering valve(s), with standard needle-type metering valve or with high accuracy (NRS) metering valve.

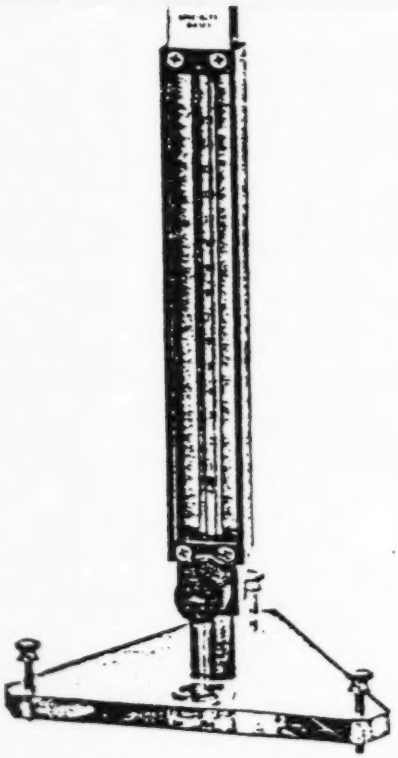
All units are dual range with two floats in each metering tube. Tube selection depends on the gas and on the range desired. See Tube Selection Table on page 35. Tubes can be easily changed or replaced without removing the flowmeter from the panel or piping system. Tubes are of heavy, precision-bore borosilicate glass with etched scales (10-150mm) on a contrasting background.

All Series 150 flowmeters have metal sideplates and end fittings with a clear plastic frontplate and opaque plastic backplate. To facilitate mounting these flowmeters, inlet and outlet adapters are externally threaded and provided with jam nuts.

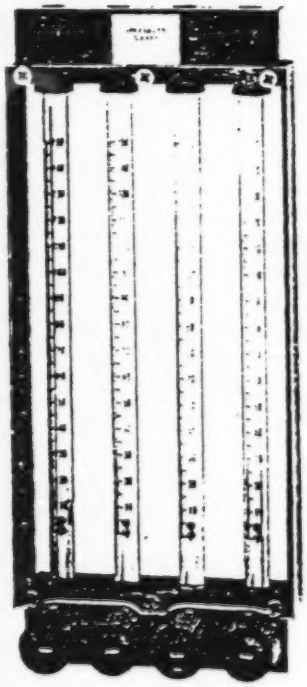
Calibration charts for air and nitrogen at normal temperature and pressure, 70°F (21°C) and 14.7 psia (101 kPa abs.), are shipped with each flowmeter or flowmeter tube at no additional charge. Calibration charts for the gases listed below can be furnished at no additional charge.

GAS CALIBRATION CHARTS FURNISHED AT NO CHARGE

Acetylene
Air
Ammonia
Argon
Arsine
Boron Trifluoride
Butane
Carbon Dioxide
Carbon Monoxide
Chlorine
Ethane
Ethylene
Ethylene Oxide
Halocarbons
Helium
Hydrogen
Hydrogen Chloride
Hydrogen Sulfide
Isobutane
Methane
Methyl Chloride
Neon
Nitric Oxide
Nitrogen
Nitrogen Dioxide
Nitrous Oxide
Oxygen
Propane
Propylene
Silane
Sulfur Dioxide
Sulfur Hexafluoride



Series 150 Single-Tube Flowmeter with Optional Base



Series 150 Four-Tube Flowmeter

SPECIFICATIONS

Maximum Operating Pressure:
200 psig (1380 kPa)
Maximum Operating Temperature:
250°F (121°C)
Calibration:
Tubes are calibrated with air at normal temperature and pressure, 70°F (21°C) and 14.7 psia (101 kPa abs.). Other calibrations are available. See Optional Equipment and Features.
Repeatability:
±0.25% of instantaneous reading
Accuracy:
±5% full scale from 100% to 10% of scale reading
Tube Graduations:
10-150mm. Air and Nitrogen calibration charts furnished with flowmeter or flowmeter tube include linear reference scale
Ranges Available:
See Tube Selection Table on page 35.
Connections:
1/8 in. NPT female (located on rear of flowmeter)
Materials of Construction:
Tubes: Borosilicate Glass with float stops of *Teflon*
Floats: Borosilicate Glass and Type 316 Stainless Steel are standard; other materials are available—see Tube Selection Table and Optional Equipment and Features.
End Fittings: See Table
Sideplates: Aluminum
Backplate: White Plastic
Frontplate: Clear Plastic
Seals and Packing: *Viton* (Buna-N furnished when meter is specified for ammonia)
Valve(s):
Models FM4302 and FM4602—Chrome-Plated Brass
All Others—Type 316 Stainless Steel

SERIES 150 SINGLE-TUBE FLOWMETERS

Part No.	Configuration	End Fittings
FM4300-*	Without Metering Valve	Aluminum
FM4301-*	With Standard Metering Valve	Aluminum
FM4302-*	With High Accuracy Metering Valve	Aluminum
FM4310-*	Without Metering Valve	Stainless Steel
FM4311-*	With Standard Metering Valve	Stainless Steel
FM4312-*	With High Accuracy Metering Valve	Stainless Steel

*Select the appropriate Series 150 Single Tube Flowmeter from the above table and complete the part number by inserting applicable tube number.
Example: FM4300-1. Order by complete part number. Tube number for the desired range can be found in the Tube Selection Table. For prices of replacement tubes, see table on page 35.

SERIES 150 FOUR-TUBE FLOWMETERS

Part No.	Configuration	End Fittings
FM4600-**	Without Metering Valves	Aluminum
FM4601-**	With Standard Metering Valves	Aluminum
FM4602-**	With High Accuracy (NRS) Metering Valves	Aluminum
FM4610-**	Without Metering Valves	Stainless Steel
FM4611-**	With Standard Metering Valves	Stainless Steel
FM4612-**	With High Accuracy (NRS) Metering Valves	Stainless Steel

** Select the appropriate Series 150 Four-Tube Flowmeter from the above table and complete the part number by inserting the tube numbers desired in the order in which they are to be installed in the flowmeter, from left to right. Example: FM4601-2314 for tube nos. 2, 3, 1 and 4. Order by complete part number. For prices of replacement tubes and floats, see tables on page 35.

OPTIONAL EQUIPMENT AND FEATURES

Part No.

Baseplates
Fits either single tube or four-tube flowmeter. FM4701
Inlet Filter
2-micron in-line filter installed in each inlet port, as illustrated.
Stainless Steel: FM4746
Aluminum: FM4741
Floats (installed)
Replaces Borosilicate Glass or Stainless Steel float material (Sapphire will replace Glass, Tantalum or Carboloy will replace Stainless Steel) - add the following to flowmeter prices:
Sapphire Float:
Tantalum Float:
Carboloy Float:
When ordering specify both float material and tube number. Includes calibration charts for air and nitrogen or any gas listed on page 33.
Calibrations: ±1% full scale calibrations are available for many gases and gas mixtures.
Gas or gas mixture and temperature and pressure must be specified.

Tube Selection Table

For Series 150 and 150K Flowmeters

REPLACEMENT TUBES (with Borosilicate Glass and Stainless Steel Floats)		
Tube No.	Part No.	
1	FM4331	
2	FM4332	
3	FM4333	
4	FM4334	
5	FM4335	
6	FM4336	

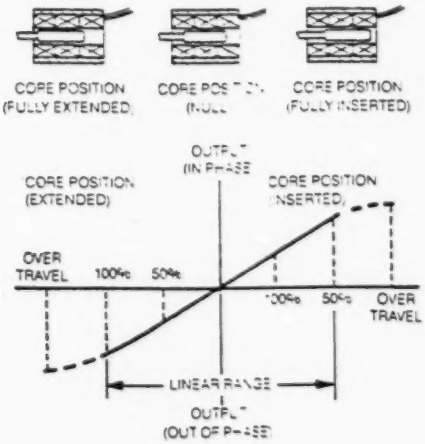
MAXIMUM FLOWRATE (MINIMUM FLOWRATE = 1/10 x MAXIMUM FLOWRATE)

Tube No.	Float Material	Argon		Carbon Dioxide		Helium		Hydrogen		Nitrogen		Oxygen		Air		Water
		Lpm	cfh	Lpm	cfh	Lpm	cfh	Lpm	cfh	Lpm	cfh	Lpm	cfh	Lpm	cfh	cm³/min
1	Glass	0.0425	0.09	0.0618	0.131	0.0481	0.102	0.1075	0.2275	0.0526	0.111	0.0466	0.0987	051	.108	0.61
	Sapphire	0.063	0.1335	0.0902	0.191	0.073	0.1545	0.1606	0.340	0.0796	0.1685	0.069	0.146	.077	.163	1.14
	316 Stn. Stl.	0.1225	0.259	0.162	0.3425	0.1468	0.315	0.3225	0.6825	0.1535	0.325	0.1355	0.287	.148	.313	2.50
	Carboloy	0.214	0.453	0.262	0.5545	0.281	0.595	0.604	1.28	0.265	0.561	0.235	0.4975	.256	.542	5.28
	Tantalum	0.232	0.491	0.282	0.597	0.290	0.614	0.660	1.397	0.286	0.6057	0.2555	0.541	.279	.592	5.84
2	Glass	0.0764	0.1617	0.111	0.235	0.0851	0.18	0.1905	0.430	0.0926	0.1955	0.08325	0.1763	.091	.193	1.02
	Sapphire	0.116	0.2455	0.1625	0.344	0.133	0.2811	0.294	0.6225	0.145	0.307	0.1255	0.2655	.139	.295	1.98
	316 Stn. Stl.	0.221	0.468	0.286	0.605	0.2655	0.562	0.593	1.255	0.273	0.578	0.242	0.514	.268	.568	4.96
	Carboloy	0.385	0.815	0.450	0.953	0.495	1.048	1.075	2.275	0.472	0.997	0.421	0.892	.454	.963	9.30
	Tantalum	0.413	0.872	0.483	1.023	0.534	1.130	1.195	2.528	0.500	1.06	0.460	0.9745	.488	1.03	10.45
3	Glass	0.322	0.681	0.3051	0.646	0.441	0.934	0.952	2.013	0.384	0.813	0.360	0.763	.378	.801	5.8
	Sapphire	0.441	0.933	0.4185	0.866	0.678	1.435	1.415	2.992	0.5265	1.114	0.487	1.031	.518	1.10	10.5
	316 Stn. Stl.	0.708	1.497	0.672	1.422	1.297	2.745	2.480	5.25	0.846	1.79	0.791	1.675	.832	1.76	20.8
	Carboloy	1.06	2.24	1.05	2.24	2.220	4.695	3.980	8.43	1.265	2.677	1.186	2.513	1.255	2.66	35.0
	Tantalum	1.132	2.39	1.075	2.274	2.420	5.12	4.190	8.875	1.352	2.86	1.267	2.685	1.33	2.82	37.8
4	Glass	1.970	4.17	2.070	4.385	4.890	10.35	7.790	16.50	2.360	4.99	2.190	4.64	2.33	4.93	53.2
	Sapphire	2.590	5.48	2.750	5.825	6.500	13.75	10.000	21.18	3.140	6.65	2.900	6.145	3.06	6.52	79.8
	316 Stn. Stl.	3.965	8.40	4.090	8.67	10.040	21.2	15.450	32.7	4.770	10.1	4.405	9.32	4.62	9.83	133.4
	Carboloy	5.730	12.13	5.750	12.18	14.69	31.05	22.70	48.06	6.850	14.5	6.420	13.6	6.75	14.36	202.0
	Tantalum	6.100	12.93	6.100	12.92	15.55	32.9	24.19	51.19	7.300	15.45	6.800	14.41	7.19	15.3	217.0
5	Glass	7.36	15.58	7.39	15.65	19.25	40.7	29.6	62.6	8.96	18.96	8.330	17.65	8.7	18.5	206.0
	Sapphire	9.56	20.25	9.52	20.16	25.6	54.2	39.0	82.55	11.5	24.38	10.700	22.68	11.3	24.0	304.0
	316 Stn. Stl.	14.06	29.77	13.85	29.3	38.8	82.35	58.2	123.2	16.85	35.7	15.80	33.4	16.5	35.2	502.0
	Carboloy	19.76	41.86	19.29	40.8	56.0	118.50	83.4	176.5	23.6	49.9	22.35	47.03	23.3	49.6	742.0
	Tantalum	20.95	44.4	20.51	43.43	59.4	125.70	87.9	186.5	25.2	53.4	23.7	50.2	24.7	52.6	798.0
6	Glass	19.6	41.5	19.46	41.2	52.95	112.10	94.2	199.2	23.6	49.9	21.75	46.0	23.12	49.2	564.0
	Sapphire	25.1	53.2	24.90	52.7	69.85	148.0	123.7	262.0	30.2	64.0	28.2	59.7	29.7	63.2	824.0
	316 Stn. Stl.	36.7	77.8	36.15	76.45	103.50	219.0	156.0	330.0	44.3	93.9	41.35	87.6	43.2	92.0	1323.0
	Carboloy	51.5	109.0	50.2	106.5	149.50	316.0	221.0	467.5	61.6	130.5	57.40	121.9	60.6	129.0	1944.0
	Tantalum	54.6	115.7	53.4	113.2	159.0	336.70	235.0	497.0	65.0	137.7	60.70	128.5	63.9	136.0	2078.0

flowrates at 21°C and 101 kPa (70°F and 14.7 psia)

PRECISION LVDT DISPLACEMENT TRANSDUCERS

The LVDT (Linear Variable Differential Transformer) is an electromechanical transducer that produces an electrical signal proportional to the displacement of a separate movable core. This rod-shaped core of magnetic steel positioned axially inside a coaxial coil assembly provides a path for magnetic flux linking the coils. When the primary coil is energized with alternating current, voltages are induced in the two tandem secondary coils.



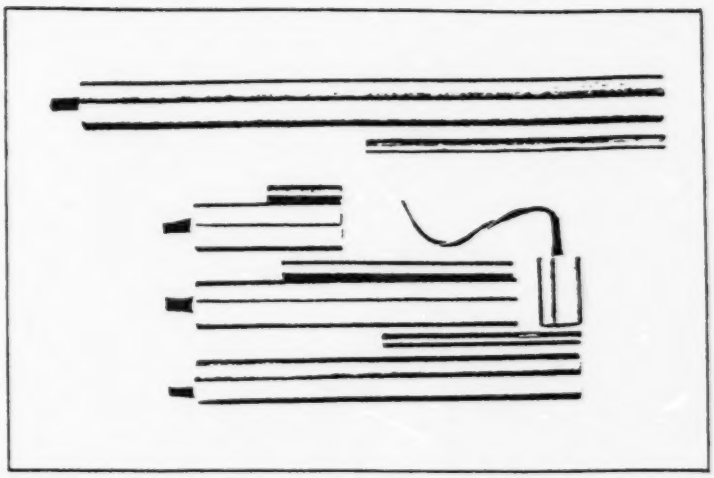
LVDT OUTPUT VOLTAGE AND PHASE AS A FUNCTION OF CORE POSITION

The secondary coils are connected in series opposition and their voltages, therefore, are opposite in phase. The net output of the LVDT is the difference between the two secondary voltages. When the core is centered, the output is zero (null position) and when the core is moved in either direction the voltage output increases proportionally and in a linear fashion.

Everett/Charles®
Marketing Services Inc.

6101 Cherry Avenue
Fontana, CA 92335
(714) 899-2411
800-443-1860
(Calif. 800-821-0589)

3845M009



LVDT TERMINOLOGY

Linearity—The comparison of actual calibration curve to the best fit straight line, expressed as maximum deviation of any calibration point from the straight line and denoted as a percentage of full range.

Scale Factor—The nominal output sensitivity expressed in terms of the ratio between the output voltage to input voltage per inch (millimeter) displacement.

Null Voltage—The residual output of an LVDT when the core is moved to a position of minimum output.

Input Frequencies—The recommended range of excitation frequencies that can be used with the LVDT. The zero phase frequency provides good temperature stability and system performance.

Phase Angle—The nominal phase angle in degrees of the output voltage compared to the input voltage.

PRICES—LINEAR PLACEMENT TRANSDUCERS

Effective January 1, 1984

General Purpose AC Series

MODEL NO.	LINEAR RANGE	PRICE EA.
050 GPA	± 0.050	$ 52.00
100 GPA	± 0.100	77.00
200 GPA	± 0.200	90.50
500 GPA	± 0.500	134.00
1000 GPA	± 1.000	160.00
2000 GPA	± 2.000	226.00

General Purpose DC Series

MODEL NO.	LINEAR RANGE	PRICE EA.
050 GPD	± 0.050	$296.00
125 GPD	± 0.125	322.00
250 GPD	± 0.250	417.00
500 GPD	± 0.500	443.50
1000 GPD	± 1.000	496.00
2000 GPD	± 2.000	548.00

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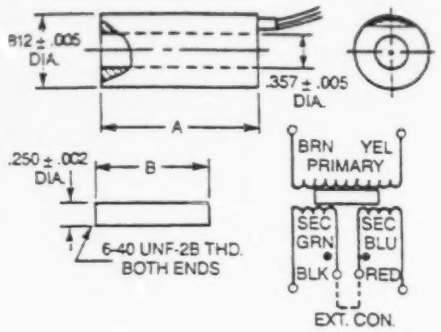
GENERAL PURPOSE AC SERIES

Leadwire Termination



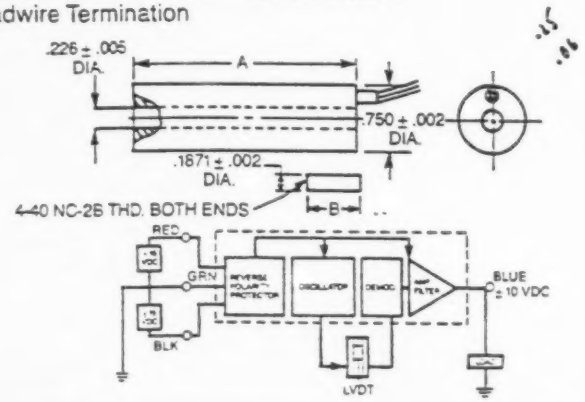
GENERAL SPECIFICATIONS

Input Voltage	6 Vrms (nominal)
Input Frequencies	50 Hz to 10k Hz
Linearity	0.25% full range
Null Voltage	0.25% F.S. Max.
Temperature Range	– 65°F to + 300°F (– 54°C to + 150°C)
Termination	Leadwires, AWG 26 copper, teflon insulated, 18" (.45m) long

Model	Linear Range Inches (mm)	LVDT Length(A) Inches (mm)	Core Length(B) Inches (mm)	Null Position (P) Inches (mm)	Nominal Scale Factor V/V/in (mV/V/mm) 400 Hz	Nominal Scale Factor V/V/in (mV/V/mm) 2500 Hz	Phase Angle (degrees) 400 Hz	Phase Angle (degrees) 2500 Hz	Zero Phase Freq. (Hz)
050 GPA	±0.050 (±1.27)	1.13 (28.7)	0.80 (20.3)	0.57 (14.5)	5.1 (200)	6.0 (240)	+24	–1	2000
100 GPA	±0.100 (±2.54)	1.81 (46.0)	1.30 (33.0)	0.91 (23.1)	4.3 (170)	4.5 (180)	+12	–5	1200
200 GPA	±0.200 (±5.08)	2.50 (63.5)	1.65 (41.9)	1.25 (31.8)	2.5 (100)	2.5 (100)	+5	–12	700
500 GPA	±0.500 (±12.70)	5.50 (139.7)	3.45 (87.6)	2.75 (69.9)	0.67 (26)	0.7 (28)	+7	–1	1500
1000 GPA	±1.000 (±25.40)	6.63 (168.4)	4.00 (101.6)	3.33 (84.6)	0.31 (12)	0.3 (12)	+5	–2	1500
2000 GPA	±2.000 (±50.80)	10.00 (254.0)	5.30 (134.6)	5.00 (127.0)	0.22 (9)	0.2 (8)	+4	–4	900

GENERAL PURPOSE DC SERIES

Leadwire Termination



GENERAL SPECIFICATIONS

Input Power	± 15 Vdc, ± 20 ma Max.
Linearity	0.25% full range or 0.5% reading whichever is greater
Ripple	1% PP F.S. Max.
Temperature Range	0°F to 158° F (– 18°C to + 70°C)
Termination	leadwires, AWG 26 copper, teflon insulated, 18" (.45m) long

Model	Linear Range Inches (mm)	LVDT Length (A) Inches (mm)	Core Length (B) Inches (mm)	Null Position (P) Inches (mm)	Scale Factor V/in (V/mm)	Output Impedance (Ohms) Max.	Minimum Load (Ohms)	Frequency Response (– 3db@ Hz)
050 GPD	±0.050 (±1.27)	2.53 (64.3)	0.59 (15.0)	0.55 (14.0)	200.0 (7.9)	10	2000	250
125 GPD	±0.125 (±3.18)	3.33 (84.6)	1.10 (27.9)	0.96 (24.4)	80.0 (3.15)	10	2000	250
250 GPD	±0.250 (±6.35)	4.19 (104.6)	1.80 (45.7)	1.39 (35.3)	40.0 (1.6)	10	2000	250
500 GPD	±0.500 (±12.70)	5.87 (149.1)	3.00 (76.2)	2.23 (56.6)	20.0 (0.8)	10	2000	125
1000 GPD	±1.000 (±25.40)	8.05 (204.5)	3.80 (96.5)	3.32 (84.3)	10.0 (0.4)	10	2000	125
2000 GPD	±2.000 (±50.80)	11.51 (292.4)	3.80 (96.5)	5.05 (128.3)	5.0 (0.2)	10	2000	125

Recu le 1986-05-28

514-935-3543

Mr. Louis Nova Ers

MARCUS TRANSFORMER of CANADA, Inc.

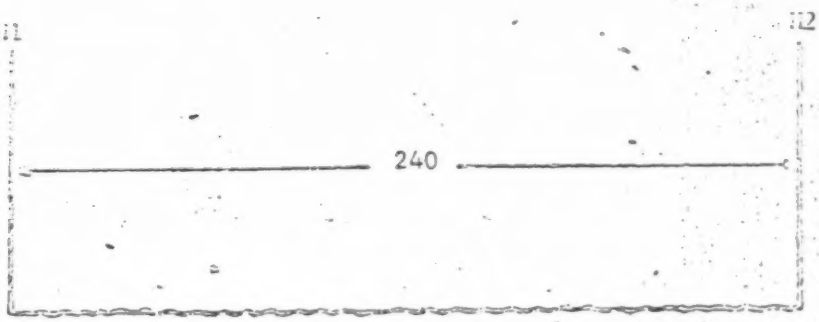
Ave Cote St-Luc

Telephone: 935-3543

900 COLLEGE STREET

MONTREAL 207, QUEBEC

CONNECTION DIAGRAM



KVA 10 60 CYCLES 1 PHASE

PRI. 240 VOLTS SECONDARY 100 VOLTS

SER. NO. 10224-586 DATE

INSTALLATION AND OPERATING INSTRUCTIONS

In order to obtain years of trouble-free service from your MARCUS TRANSFORMER follow the simple instructions given below:

LOCATION: In dry type transformers, air circulation through the windings is essential in the dissipation of the heat resulting from the transformer losses. It is thus evident that to insure long service this transformer should be located indoors in a location that is reasonably dry and cool and free from excessive dust, oil vapors and acid fumes. Important: always mount transformer so that the openings in the case are at the top and bottom, thus assuring maximum natural draft. Keep floor mounted units at least four inches from wall.

When the transformer is first turned on, a loud hum may be heard for an instant. This is a normal condition, the intensity of which is governed primarily by the point on the A.C. wave at which the transformer is turned on. This will diminish after a few cycles.

GENERAL: Because the iron loss in a transformer is the same at no load as it is at full load, the core will heat up even while the transformer is not carrying a load and is just floating on the line... This transformer is constructed with heatproof materials and can therefore operate at a higher temperature rise than an ordinary transformer built with cotton, paper and enamel insulated conductors.

SURGE PROTECTION: All dry type transformers inherently have a lower basic impulse level (BIL) than liquid filled units. If the installation is made in an area where the transformer or the lines are exposed to voltage surges due to lightning, switching, etc., arresters should be installed as close as possible to the transformer terminals. The use of type RM lightning arresters of proper voltage rating is reccomended.

SOUND LEVEL: All transformers have an inherent sound level. Alternating magnetic flux is the factor which causes the emanation of sound. Generally speaking, these vibrations have a pitch of twice the applied frequency. The larger transformers emit a greater volume of sound than the smaller ones. The actual noise level of the transformers, as tested at the factory, is not necessarily the noise level that will be evident on the job site. Very often, sound is amplified by a poor choice of the installation site. For instance, a close proximity to bare concrete walls or sheet metal results in a "sounding board" effect.

FOR MINIMUM SOUND LEVEL ON JOB SITE OBSERVE FOLLOWING INSTALLATION PRECAUTIONS:

1. Avoid installation near a sound-reflecting surface.
2. Avoid installation under stairs or in narrow hallways.
3. If possible, choose location where sound would be least objectionable.
4. Try to avoid tile, masonry, brick, or steel walls as installation sites. If this cannot be avoided, be sure to use an acoustic-absorbing material between transformer and sound-reflecting surface.
5. Avoid mechanical coupling between transformer and building stucture.
6. Avoid mounting on walls, ceilings, or floors of relatively light mass.
7. Avoid mounting surfaces that are not even.
8. Avoid the use of rigid conduit or bus connections. These may transmit vibrations through leads to building structure.
9. Weight of mounting area relative to the area of the transformer should be greater than the weight of the transformer to minimize vibration characteristics.
10. The use of a vault, in itself, is no protection against sound emanation. The structural design of the vault, and conduit and duct connections must be considered.

THE OBSERVANCE OF THESE INSTALLATION PRECAUTIONS WILL ALLOW THE FULL REALIZATION OF THE LOW DECIBEL LEVEL FOR WHICH MARCUS TRANSFORMERS ARE DESIGNED.

MARCUS TRANSFORMERS CONFORM TO THE STANDARD OF C.S.A.

MARCUS TRANSFORMER of CANADA, LTD.

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